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ABSTRACT

This book consists of four sections: (1) "Supplemental Materials"; (2) "Supplemental Investigations"; (3) "Test Item Bank"; and (4) "Blackline Masters." The first section provides additional background material related to selected chapters and investigations in the student book. Included are a periodic table of the elements, genetics problems and solutions, and background information on acquired immune deficiency syndrome (AIDS). The second section includes 17 investigations that can be used in addition to or in place of investigations in the student book. The investigations have been placed in approximate order of their relevance to the chapters. Each investigation contains a list of materials, procedures, and discussion questions. The next section contains more than 2,000 multiple-choice test items, arranged according to the chapters in the Biological Sciences Curriculum Study (BSCS) Green Version textbook. The final section contains blackline masters that can be copied for students to use as worksheets or to make overhead transparencies. (CW)

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SE 049 757

Teacher's Resource Book and Test Item Bank for

BIOLOGICAL SCIENCE: An Ecological Approach

Sixth Edition

BSCS Green Version

The Colorado College
Colorado Springs, Colorado

Jean P. Milani, BSCS, Green Version Revision Coordinator

Kendall/Hunt
Publishing Company
Dubuque, Iowa

BSCS Production Staff
Anthony A. Hauk
Thelma G. Hyson
Douglas J. Robert
Doug Sokell
Katherine A. Winternitz

BSCS Administrative Staff
Jane Butler Kahle, Chair, Board of Directors
Joseph D. McInerney, Director

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Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

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Introduction

The Teacher's Resource Book consists of four sections. Supplemental Materials, Supplemental Investigations, Test Item Bank, and Blackline Masters.

Supplemental Materials provides additional background material related to certain chapters and investigations in the student book. The Invitations to Enquiry referenced in the Teacher's Edition will become a part of this section when available. The Invitations to Enquiry originally appeared in the BSCS *Biology Teacher's Handbook*, 3rd ed., 1978 (New York: Macmillan Publishing Company), which was declared out of print subsequent to the release of the Green Version. This section also will accommodate updates and teacher input which Kendall/Hunt Publishing Company will provide on a periodic basis.

Supplemental Investigations includes 17 investigations that can be used in addition to or in place of investigations in the student book. The investigations have been placed in approximate order of their relevance to the chapters.

The Test Item Bank consists of the Resource Book of Test Items in print and on disk. The Bank contains more than 2000 multiple-choice test items. More than one fourth of the items are new for the sixth edition; the others have been reorganized and revised to match the new chapter sequence and content.

Blackline Masters can be copied for students to use as worksheets or used to make overhead transparencies. Art and diagrams from the Green Version were selected on the basis of their potential usefulness in discussion and in clarification of difficult concepts.

Supplemental Materials

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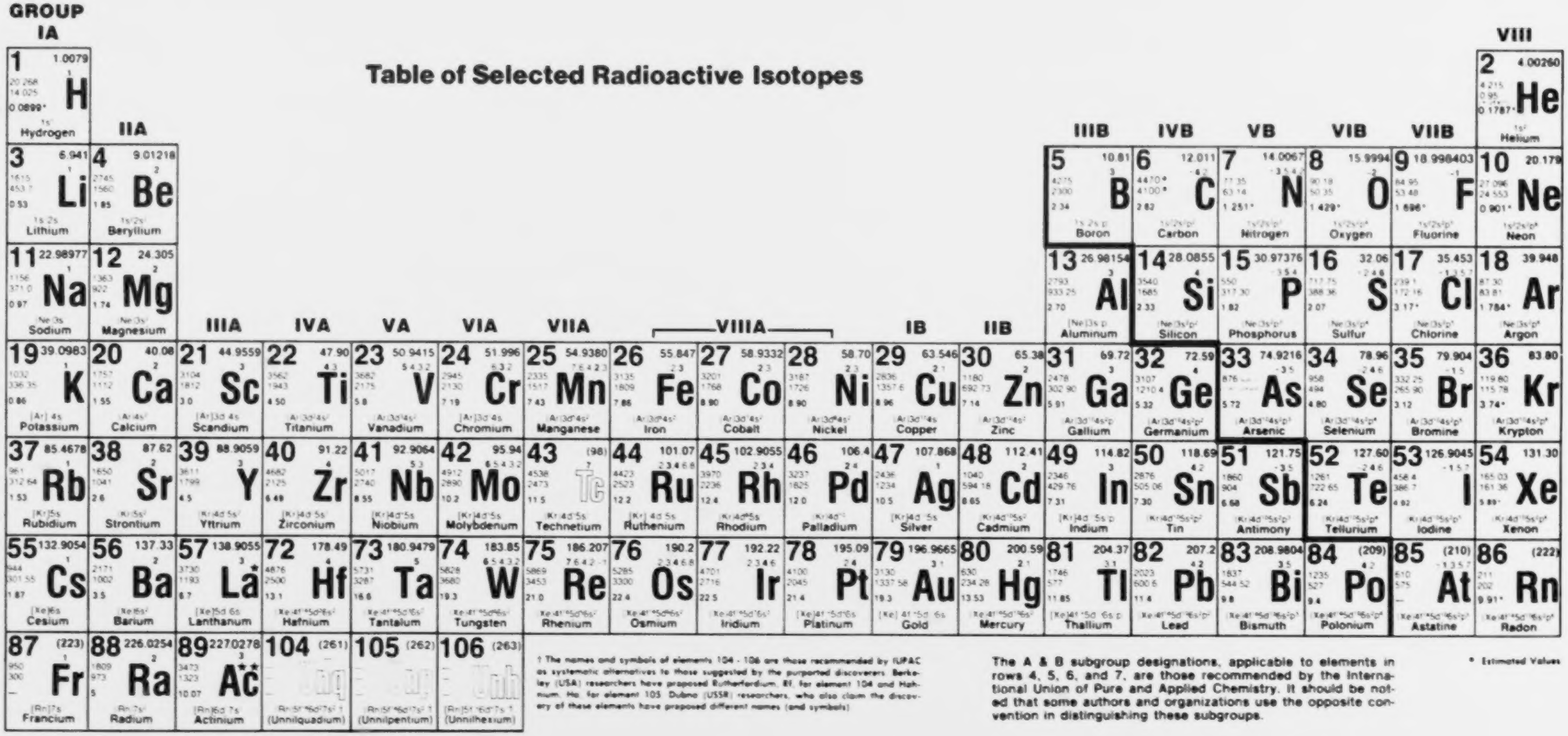
Periodic Table of the Elements

Table of Selected Radioactive Isotopes

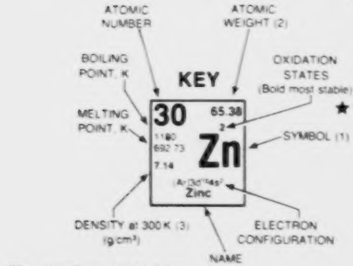


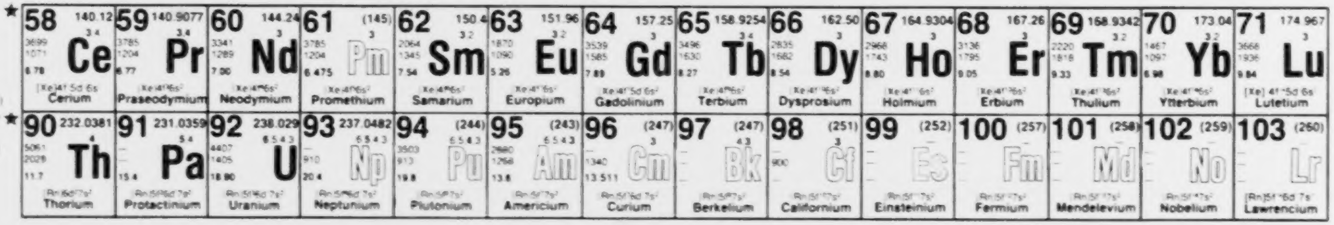
IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA			IB	IIB	IIIB	IVB	VB	VIB	VIIB	VIII
1 H Hydrogen 1.0079																	2 He Helium 4.00260
3 Li Lithium 6.941	4 Be Beryllium 9.01218											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.179
11 Na Sodium 22.98977	12 Mg Magnesium 24.305											13 Al Aluminum 26.98154	14 Si Silicon 28.0855	15 P Phosphorus 30.97376	16 S Sulfur 32.06	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.08	21 Sc Scandium 44.9559	22 Ti Titanium 47.90	23 V Vanadium 50.9415	24 Cr Chromium 51.996	25 Mn Manganese 54.9380	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.70	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.59	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.9059	40 Zr Zirconium 91.22	41 Nb Niobium 92.9064	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.4	47 Ag Silver 107.868	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.69	51 Sb Antimony 121.75	52 Te Tellurium 127.60	53 I Iodine 126.9045	54 Xe Xenon 131.30
55 Cs Cesium 132.9054	56 Ba Barium 137.33	57 La ★ Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.2	77 Ir Iridium 192.22	78 Pt Platinum 195.09	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.37	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium 226.0254	89 Ac ★★ Actinium 227.0278	104 Unq (Unnilquadium) (261)	105 Unp (Unnilpentium) (262)	106 Unh (Unnilhexium) (263)												

† The names and symbols of elements 104 - 106 are those recommended by IUPAC as systematic alternatives to those suggested by the purported discoverers. Berkeley (USA) researchers have proposed Rutherfordium, Rf, for element 104 and Hahnium, Ha, for element 105. Dubna (USSR) researchers, who also claim the discovery of these elements have proposed different names (and symbols).

The A & B subgroup designations, applicable to elements in rows 4, 5, 6, and 7, are those recommended by the International Union of Pure and Applied Chemistry. It should be noted that some authors and organizations use the opposite convention in distinguishing these subgroups.

* Estimated Values





★	58 Ce Cerium 140.12	59 Pr Praseodymium 140.9077	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.4	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9254	66 Dy Dysprosium 162.50	67 Ho Holmium 164.9304	68 Er Erbium 167.26	69 Tm Thulium 168.9342	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
★★	90 Th Thorium 232.0381	91 Pa Protactinium 231.0359	92 U Uranium 238.029	93 Np Neptunium 237.0482	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (260)

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Genetics Problems

1. The polled (hornless) trait in cattle is dominant. The horned trait is recessive. A certain polled bull is mated to three cows. Cow A, which is horned, gives birth to a polled calf. Cow B, also horned, produces a horned calf. Cow C, which is polled, produces a horned calf. What are the genotypes of the four parents?

2. In shorthorn cattle, when a red bull (C^RC^R) is crossed with a white cow (C^WC^W), the offspring are roan (intermingled red and white hairs). How could a rancher establish a herd of roan cattle?

3. In sheep, white coat is dominate. Black is recessive. Occasionally, a black sheep appears in a flock. Black wool is worthless. How could a farmer eliminate the genes for black coat from the flock?

4. In summer squash, white fruit color is dominant. Yellow is recessive. A squash plant that is homozygous for white is crossed with a homozygous yellow one. Predict the appearance of: (a) the F_1 generation, (b) the F_2, and (c) the offspring of a cross between an F_1 individual and a homozygous white individual.

5. The storage roots of radishes may be long, round or oval. In a series of experiments, crosses between long and oval produced 159 long and 156 oval. Crosses between round and oval produced 199 round and 203 oval. Crosses between long and round produced 576 oval. Crosses between oval and oval produced 121 long, 243 oval and 119 round. Show how root shape is inherited in radishes.

6. In tomatoes, red fruit color is dominant to yellow. Round-shaped fruit is dominant to pear-shaped fruit. Tall vine is dominant to dwarf vine.
   (a) If you cross a pure-breeding tall plant bearing red, round fruit with a pure-breeding dwarf plant bearing yellow, pear-shaped fruit, predict the appearance of the F_1 generation.
   (b) Assuming that the gene loci controlling the three traits are in three different pairs of chromosomes, what are the possible genotypes in the F_2 generation?
   (c) What are the expected ratios of the phenotypes?

7. What are the possible blood types of children in the following families?
   (a) Type A mother, Type A father
   (b) Type A mother, Type O father
   (c) Type B mother, Type AB father
   (d) Type AB mother, Type AB father
   (e) Type A mother, Type B father

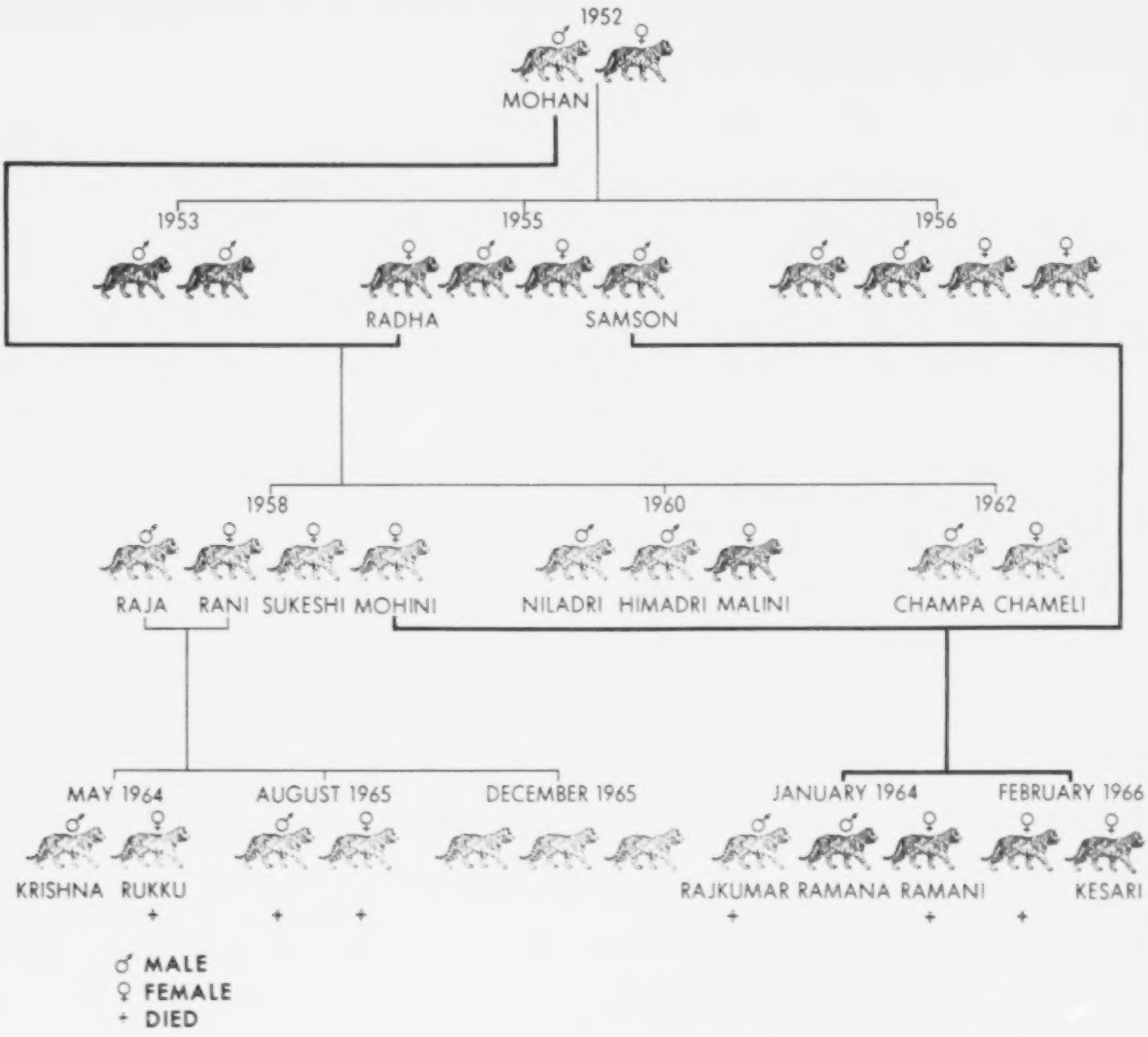
8. Before Mendel, the chief theory of heredity was "blood-line inheritance." According to this theory, the parents' traits are blended in the offspring, just as two liquids blend when mixed together. Mendel's theory rested on the idea that traits are transmitted by particles (genes) and do not blend. Give evidence in support of the older theory. Then show how the results of Mendel's experiments fail to fit that theory.

9. How would you go about improving the characteristics of the seedless orange?

10. At the present time, there is no such thing as an all-blue tulip. The first one found will be quite valuable. How might a tulip breeder increase the chances of finding a blue tulip?

11. Suppose you examined the cells of a species of plant and found 12 chromosomes: a long straight pair, a short straight pair, a medium-length pair, a long bent pair, a short bent pair, and a medium-length bent pair. You then breed the plants of this species for several generations.
    (a) At the end of this time would you expect to find some plants with all the straight chromosomes and none of the bent ones? All of the bent ones and none of the straight ones? Explain.
    (b) What proportion of the gametes should have 3 straight chromosomes and 3 bent ones? 4 straight and 2 bent? 6 bent?

GENEALOGY OF CAPTIVE WHITE TIGERS


1952
♂
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MOHAN
1953
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1955
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RADHA
SAMSON
1956
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1958
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RAJA
RANI
SUKESHI
MOHINI
1960
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NILADRI
HIMADRI
MALINI
1962
♂ ♀
CHAMPA
CHAMELI
MAY 1964
♂ ♀
KRISHNA
RUKKU +
AUGUST 1965
♂ + ♀ +
DECEMBER 1965
JANUARY 1964
♂ ♂ ♀
RAJKUMAR +
RAMANA
RAMANI +
FEBRUARY 1966
♀ + ♀
KESARI
♂ MALE
♀ FEMALE
+ DIED

National Zoological Park Washington, D.C. April 1, 1966

12. A die (singular of dice) has six sides. What is the probability that an even number will come up on one throw of a die?

13. If base pairs in DNA molecules can consist only of adenine-thymine or cytosine-guanine, what must be the ratio of the amount of adenine to thymine? Of the amount of cytosine to guanine? Of adenine to cytosine?

14. The pedigree in the figure above shows the descendants of Mohan, a white tiger captured in India. Assuming that whiteness in tigers is a single-locus trait, is it recessive or dominant? What evidence supports your answer?

15. In garden peas, tall vine is dominant and short vine is recessive. If a homozygous tall plant is crossed with a homozygous short plant, what genotypes are possible in the F_1 generation?

16. In garden peas, inflated pod is dominant and constricted pod is recessive.
    (a) If a plant homozygous for inflated pod is crossed with a plant homozygous for constricted pod, what ratio of phenotypes would you expect to find in the F_2 generation?
    (b) What ratio of genotypes would you expect?

17. In guinea pigs, short hair is dominant and long hair is recessive. A short-haired male and a short-haired female produced mostly short-haired offspring, but a few were long-haired. Show how you can determine the genotypes of the parents.

18. In laboratory mice, the normal gray color is dominant over the albino (all-white) color. Starting with purebred albino and purebred gray as parents, what is the ratio of phenotypes in the F_2 generation?

19. A pea plant that was homozygous for axial flowers (the dominant strain) was crossed with a plant that was homozygous for terminal flowers.
    (a) What ratio of genotypes would you expect in the F_2 generation?
    (b) What ratio of phenotypes would you expect?

20. In the following cases, Z stands for a certain dominant gene and z stands for a certain recessive gene. What ratios of genotypes would you expect from the following crosses:
    (a) $ZZ \times zz$,
    (b) $Zz \times Zz$,
    (c) $Zz \times zz$,
    (d) $Zz \times ZZ$?

21. In a certain species of plant, one purebred variety has hairy leaves and another purebred variety has smooth leaves. A cross of the two varieties produces offspring that all have smooth leaves. Predict the ratio of phenotypes in the F_2 generation.

22. In corn, yellow seed color is dominant and white is recessive. A certain ear of corn had a mixture of yellow seeds and white seeds. What color seeds could the parents have grown from?

23. In a certain animal, a breed is known that always has a hairy tail; another breed is known that always has a naked tail. How would you determine which trait is dominant?

24. In garden peas, axial flower position is dominant and terminal flower position is recessive; tall vine is dominant and short vine is recessive. A plant known to be purebred for tall vine and axial flowers is crossed with a plant having short vines bearing terminal flowers.
    (a) What is the phenotype of the offspring?
    (b) What is the genotype of the offspring?
    (c) Predict the kinds of offspring (phenotypes) that would appear in the F_2 generation and their ratios.

25. In snapdragons, red flower color (C^R) is codominant with white (C^W), the heterozygotes being pink; the normal (broad) leaves (L^B) are codominant with narrow (grass-like) leaves (L^N), the heterozygotes having leaves of medium breadth. If a red-flowered, broad-leaved plant is crossed with a white-flowered, narrow-leaved one, what will be the phenotypes and their expected ratio in the F_2 generation?

26. Several different genetic situations are described below. In each case, you are to decide which of the following kinds of inheritance are involved:
    (a) codominance
    (b) linkage with little or no crossing over
    (c) two genes on different chromosomes
    (d) several to many genes on different chromosomes
    (e) multiple alleles
    (f) linkage with a high percentage of crossing-over

Situation 1: You have a number of plants belonging to an F_2 generation. About 1/4 have no thorns, about 1/4 have long thorns, and about 1/2 have short thorns. What kind of inheritance is involved?

Situation 2: In another set of plants, also of an F_2 generation, you find the following phenotype ratios: 9 red flowers and broad leaves; 3 red flowers and narrow leaves; 3 white flowers and broad leaves; 1 white flower and narrow leaves. What kind of inheritance is involved?

Situation 3: You discover a species of bird. In the population some have long crests on their heads, some have scarcely any crests, and many have crests showing all possible intermediate lengths. What kind of inheritance is involved?

Situation 4: In a certain species of insect, 3 eye colors are known: red, orange, and yellow. If purebred red-eyed individuals are crossed with purebred orange-eyed, all the offspring are red-eyed. If purebred orange-eyed are crossed with purebred orange-eyed, all the offspring are orange-eyed. If purebred red-eyed are crossed with purebred yellow-eyed, all the offspring are red-eyed. What is the most likely method of inheritance?

Situation 5: In another case in which you study 2 traits of a plant at the same time, you find in the F_2 generation that 3/4 have hairy stems and green seeds while the other 1/4 have smooth stems and brown seeds. What kind of inheritance is involved?

Situation 6: Among many varieties of popcorn, 1 has an average ear length of 6 cm (ranges from 4 to 9) and another has an average ear length of 16 cm (ranges from 12 to 19). When the 2 varieties are crossed, the F_2 offspring have ears with an average length of 11 cm (ranges from 5 to 19). What is the most likely method of inheritance?

Situation 7: The F_2 generation of a dihybrid cross in a plant showed the following ratio of phenotypes: 66% had hairy stems and round fruit; 9% had hairy stems and pear-shaped fruit; 9% had smooth stems and round fruit; 16% had smooth stems and pear-shaped fruit. What kind of inheritance is involved?

27. In poultry, rose comb is dependent on a dominant factor, ***R***, single comb on its recessive allele ***r***. A rose-combed male is mated with 2 rose-combed females. Female A produces 14 chicks, all rose-combed. Female B produces 9 chicks, 7 rose-combed and 2 single-combed. What are the genotypes of the 3 parent birds?

28. The Jones family has eight children, all of whom are girls. What is the chance that the next child will be a boy? Explain.

29. A brown mouse is crossed with a heterozygous black mouse. If the mother has a litter of four, what are the chances that all of them will be brown?

30. In man, normal pigmentation is due to a dominant factor ***C***, albinism to its recessive allele ***c***. A normal man marries an albino woman. Their first child is an albino.
    (a) What are the genotypes of these three people?
    (b) If they have more children, what would they probably be like?
    (c) An albino man marries a normally pigmented woman. They have nine children, all normally pigmented. What are the genotypes of the parents and the children?

31. In dogs, wire hair is due to a dominant factor, smooth hair to its recessive allele. Two wire-haired dogs produce a male puppy which is wire-haired. To what kind of female should he be mated to find out most quickly whether he carries the factor for smooth hair?

13

32. In guinea pigs, the coat may be rough or smooth. Certain rough-coated guinea pigs, when crossed with smooth-coated ones, produce all rough-coated offspring. Other rough-coated guinea pigs, when crossed with smooth-coated ones, produce equal numbers of rough-coated and smooth-coated offspring. Smooth-coated guinea pigs crossed together always produce smooth-coated offspring. Explain these results. Write the genotypes for all the animals concerned in the crosses.

33. What kinds of gametes would be produced by organisms having the following genotypes:

    (a) ***AaBB***, (b) ***aaBB***, (c) ***AAbb***, (d) ***AaBBCc***.

34. In horses, black is due to a dominant gene ***B***, chestnut to its recessive allele ***b***. The trotting gait is due to a dominant gene ***T***, pacing to its recessive allele ***t***.

    (a) If a homozygous black pacer is mated to a homozygous chestnut trotter, what will be the appearance of the F_1 generation?
    (b) If two F_1 individuals were mated, what kinds of offspring could they have, and in what proportions?
    (c) If an F_1 male were mated to a homozygous female black pacer, what kinds of offspring could be produced, and in what proportions?

35. In cocker spaniels, black is due to a dominant factor ***B***, red to its recessive allele ***b***. Solid color is dependent upon a dominant factor ***S***, white spotting upon the recessive allele ***s***. A red male was mated to a black-and-white female. They had 5 puppies, as follows: 1 black, 1 red, 1 black-and-white, and 2 red-and-white. What were the genotypes of the parents?

Solutions for Genetics Problems

1. Bull = heterozygous for polled; Cow A = homozygous for horned; Cox B = homozygous for horned; Cow C = heterozygous for polled.

2. A herd of only roan cattle could not be independently maintained. If any breeding were allowed, both red and white offspring would soon occur. Of course, the rancher could maintain a herd by adding only the offspring of red and white cows (not considered a part of the herd) and preventing the roan animals from interbreeding.

3. The farmer should eliminate from the flock both parents and all offspring whenever a black sheep appears.

4. (a) F_1 = all white; (b) F_2 = 3/4 white and 1/4 yellow. (c) A cross between an F_1 individual and a homozygous white individual would produce only white offspring.

5. The results of these breeding experiments can be explained on the basis of codominance.

6. (a) The F_1 generation consists entirely of individuals that are tall and have red, round fruit.
   (b) ***P*** = round, ***T*** = tall, ***R*** = red: 1/64 ***PPTTRR***, 1/32 ***PpTtRR***, 1/32 ***PpTTRR***, 1/16 ***PpTtRR***, 1/32 ***PPTTRr***, 1/16 ***PPTtRr***, 1/16 ***PpTTRr***, 1/8 ***PpTtRr***, 1/64 ***PPTtRr***, 1/32 ***PpttRR***, 1/32 ***PPttRr***, 1/16 ***PpttRr***, 1/64 ***ppTTRR***, 1/32 ***ppTtRR***, 1/32 ***ppTTRr***, 1/64 ***ppttRR***, 1/16 ***ppTtRr***, 1/32 ***ppttRr***, 1/64 ***PPTTrr***, 1/32 ***PPTtrr***, 1/32 ***PpTTrr***, 1/16 ***PpTtrr***, 1/64 ***PPttrr***, 1/32 ***Ppttrr***, 1/64 ***ppTTrr***, 1/32 ***ppTtrr***, 1/64 ***ppttrr***.
   (c) Round, tall, red—27/64. Pear, tall, red—9/64. Pear, dwarf, red—3/64. Round, tall, yellow—9/64. Round, dwarf, yellow—3/64. Pear, tall, yellow—3/64. Peal, dwarf, yellow—1/64.

7. (a) A or O children; (b) A or O children; (c) A, B, or AB children; (d) A, B or AB children; (e) A, B, AB or O children.

8. Codominance could be interpreted by a bloodline theory of inheritance. Also, phenotypic characteristics that are the result of the interaction of several genes could be so interpreted. However, Mendel's results, all of which fortuitously involved simple traits exhibiting the dominance phenomenon, were impossible to interpret by any kind of blending theory.

9. Because sexual reproduction is lacking, a new trait would depend on a somatic mutation in a meristem cell, from which bud and shoot carrying the mutation might develop. The likelihood that it will occur normally is small, but it can be increased by using radiation; at any rate, certain mutated characteristics can be maintained with grafting.

10. The problem involves the production of mutations, one of which, by chance, might be the desired characteristic. Anything, then, that might increase the mutation rate would be desirable.

11. (a) No; No; As the result of mitosis, each offspring cell has chromosomes identical to those of the parent cell. (b) All of them; None of them; None of them.

12. Since there are 3 even numbers on the die (2, 4 and 6) there are 3 ways in which the conditions of the question can be met; therefore, the probability is 3/6, 1/2, 0.5, or 50%.

13. Adenine to thymine, 1:1; Cytosine to guanine, 1:1, Adenine to cystosine (or any other mismatched pair), indeterminate.

14. The 1953, 1955, and 1956 litters suggest that white coat color is not dominant. Were it a dominant autosomal gene, either 1/2 or all 10 of the offspring in these 3 litters should have been white. On the other hand, if white were an x-linked dominant gene, then the 4 daughters in these early litters would have been white. Radha, a tigress that must be heterozygous for white coat color, produced 1 yellow and 4 white female cubs; thus confirming her heterozygosity. All 4 of her sons were white, and so, through 1962, no critical evidence was available on the matter of x-linkage versus autosomal inheritance. In 1964, however, Mohini produced Ramana, a yellow male cub. Therefore, the gene for white coat color cannot be on the X chromosome—if it had been, all of Mohini's sons would have been white. White coat color in tigers, therefore, is determined by a recessive autosomal gene.

15. Only heterozygous dominant, ***Tt.***

16. (a) 3:1 inflated to constricted; (b) 1:2:1 ***PP*** : ***Pp*** : ***pp***.

17. Short hair is dominant, so the parents could have been ***SS*** × ***SS***, ***SS*** × ***Ss***, or ***Ss*** × ***Ss***. A few offspring had long hair, the recessive trait. They must have obtained a gene for that trait from each parent, so both parents had to be ***Ss***.

18. 3:1, gray to albino.

19. (a) 1:2:1, ***AA*** : ***Aa*** : ***aa;*** (b) 3:1, axial to terminal.

20. (a) 4:1, (b) 1:2:1; (c) 1:1; (d) 1:1.

21. 3:1, smooth to hairy.

22. The seeds from which the parents grew could have been both yellow (***Yy*** × ***Yy***) or one yellow and one white (***Yy*** × ***yy***).

23. Cross the two breeds.

24. (a) Offspring are tall, with axial flowers. (b) ***TtAa.*** (c) 9 tall with axial flowers, to 3 tall with terminal flowers, to 3 short with axial flowers, to 1 short with terminal flowers (9:3:3:1).

25. It will be a mix of red flowers with broad, medium and narrow leaves, the same for white and pink flowers. Red-flowered and white-flowered plants will each have a ratio of 1:2:1, broad to medium to narrow leves, and the pink-flowered plants will have a ratio of 2:4:2, broad to medium to narrow leaves.

26. Situation 1: (a)
Situation 2: (c)
Situation 3: (d)
Situation 4: (e)
Situation 5: (b)
Situation 6: (d)
Situation 7: (f)

27. Male = ***Rr;*** Female A = ***RR;*** Female B = ***Rr.***

28. 50%. There are only 2 possibilities.

29. The chance for brown is 1/2; for 4 brown, $(1/2)^4 = 1/16$.

30. (a) ***Cc, cc, Cc.*** (b) 50% normal and 50% albino. (c) The male is ***cc***, the female ***CC*** and the children ***Cc.***

31. A female with smooth hair.

32. The explanation is simple Mendelian inheritance with rough coat dominant and smooth coat recessive. Cross 1: ***RR*** × ***rr*** = ***Rr;*** Cross 2: ***RR*** × ***RR*** = ***RR;*** Cross 3: ***rr*** × ***rr*** = ***rr.***

33. (a) ***AB, aB;*** (b) ***aB;*** (c) ***Ab;*** (d) ***ABC, ABc, aBc.***

34. (a) ***BbTt***, black trotter; (b) 9 black trotters, 3 black pacers, 3 chestnut trotters and 1 chestnut pacer; (c) 1 black trotter to 1 black pacer.

35. The male is ***bbSs***, and the female is ***Bbss.***

What Is Aids?

(Background Information for Investigation 11.3)

AIDS is a disease of the immune system that is usually acquired after birth by people who previously had perfectly normal immune responses. Other immune deficiency diseases are either acquired during the development of the fetus, or last only a short time, usually following an illness. AIDS is caused by a virus that invades and destroys cells of the immune system. By the fall of 1986 approximately 26,000 people had been diagnosed as having AIDS. The Centers for Disease Control estimates that the number could rise to 270,000 by 1991.

How does this virus cause AIDS? There are very few viruses that can invade cells of the immune system, and most of them are cancer-causing viruses. Interestingly, although there is no evidence that the AIDS virus actually causes cancer, it is a close relative of viruses that can cause leukemia—one type of cancer. The AIDS virus enters a cell of the immune system, where it multiplies and eventually kills the cell, releasing other viruses that invade more of the same kind of cells.

This virus will not invade all cells of the immune system, but prefers a certain kind of cell, called a helper T cell. The role of helper T cells is to help other cells of the immune system do their jobs. Without that help, the other cells function very poorly.

AIDS results from the destruction of helper T cells. The patient, therefore, becomes highly susceptible to many kinds of infections and tumors. Indeed, the hallmark of AIDS is the presence of parasitic, fungal, and viral diseases. In addition, there is an increase in a number of different kinds of cancer, most often a type called Kaposi's sarcoma, which is normally very rare. The AIDS virus does not cause the disease directly; the disease AIDS is the result of massive infections by many types of organisms because the immune response to them does not occur.

How Do You Get AIDS?

In order to get AIDS, the virus must be introduced into the body. Most commonly, that occurs through sexual contact. The virus has been found in the semen of infected males. Approximately two-thirds of the reported cases as of early 1987 occurred in homosexual and bisexual males. We do not know why the disease in this country began among homosexual males; there are other viral diseases, such as hepatitis, that are more common among homosexuals than in the general population. However, heterosexual transmission is an increasingly serious problem. Most scientists now believe that any person infected with the AIDS virus can transmit the virus by sexual contact, regardless of the sex of the partner.

Most of the remaining infected individuals (about 17 percent) are drug addicts who use intravenous injections and share needles. If one individual has the virus in his or her blood, another person using that same hypodermic needle can inject the virus into his or her own blood, and subsequently develop the disease. (You cannot acquire the infection from an injection given to you by a doctor or other health professional because ALL of the needles they use are destroyed after one use. There is no way they can be contaminated by another person's blood, even in a blood bank.) The remaining AIDS cases are hemophiliacs and other recipients of multiple blood transfusions, and babies born to infected mothers. Because the virus can cross the placenta, an infected mother can transmit the virus, and hence the disease, to her unborn baby.

Misconceptions

There are many common misconceptions about AIDS and how it is transmitted. Although the virus has been detected in low amounts in the saliva of some infected people, there is no evidence as yet that it can be transmitted effectively through saliva. A person sneezing or chewing on a pencil or spitting in the water fountain will not be able to transmit the virus effectively. The virus cannot be transmitted on toilet seats or through towels. You will not get it from the swimming pool or from the locker-room floor.

AIDS is NOT transmitted through casual contact, even in a family setting. The only family members of an AIDS patient who have contracted the disease have done so by sexual contact or blood transfusion, or else have contracted the disease *in utero*, before birth. Of the thousands of doctors, nurses, orderlies, and other hospital personnel who work with AIDS patients, few have gotten the disease, and those who have were either homosexuals (or bisexuals), recipients of multiple blood transfusions, or sexual partners of AIDS patients. Only one health care worker is reported to have contracted the disease from an AIDS patient. That resulted from a needlestick injury and exposure to the blood of the patient.

Prospects for Treatment

Why can we not treat AIDS effectively? Maybe we will be able to, and maybe soon. However, there are two important things to remember about AIDS. First, it is caused by a virus. Today, we have only a few drugs that can control or prevent any viral infections.

There is hope, however. The genes of the AIDS virus are made up of RNA instead of DNA. In order to multiply, the virus must make DNA from its RNA. It must then replicate its DNA, and make a new RNA. Human and other animal cells cannot make DNA from RNA; they can only do the opposite, that is, make RNA from DNA. Viruses whose genes are made of RNA have an enzyme that allows them to accomplish this tricky biochemical feat. Animal cells lack this enzyme. If a drug could be found to inhibit this enzyme, and no other, then it should be able to prevent the AIDS virus from replicating without harming the infected cell.

There are some drugs that can do this, at least in the test tube. A drug developed in mid 1986, AZT, attaches to the enzyme—reverse transcriptase—in test tubes. AZT reduces the number of opportunistic infections AIDS patients get and prolongs survival for a few months. There are some severe side effects from the drug, and it is still experimental. Researchers are not sure that AZT works in the body the same way it works in the test tube. Studies are still in progress.

The second reason that AIDS is difficult to treat is that the disease only occurs after the helper T cells have been destroyed. Even if we had a drug that could kill the virus, it might be too late to save an AIDS patient; it takes a long time to regenerate the immune system, and the patient may die of other infections before then. Many of the infections that AIDS patients get cannot be treated by any of the drugs we have today.

Can we develop a vaccine to prevent AIDS? Yes, but it will take some time. There is a tremendous amount of research being done to develop an AIDS vaccine, and there are some promising results from animal experiments. However, it will take several years to develop a vaccine that can be used safely in humans. A vaccine always carries a risk, and the worst situation would be for the vaccine itself to cause AIDS. Other side effects could occur, and the relative risks and benefits would have to be evaluated for this vaccine just as they are for any other.

Many Questions Remain

Will AIDS become a serious venereal disease in the general, heterosexual population—something like genital herpes or gonorrhea? It might. The AIDS virus clearly can be transmitted by heterosexual contact. It is a good idea to be certain that you sexual partner has not been exposed to the AIDS virus.

Can AIDS be transmitted by kissing? The evidence suggests that this is not likely, but some experts feel that prolonged "deep kissing" (tongue kissing) might be sufficient to transmit the virus. In general, the AIDS branch of the Centers for Disease Control states: "Heterosexual transmission . . . appeared to be most closely associated with being a steady heterosexual partner of a person with AIDS or of a seropositive individual (person who has AIDS anitbody) in a risk group."

AIDS will remain a serious problem among homosexuals, bisexuals, and intravenous drug users for a long time. It is already a major cause of death among males 25–44 years of age in Manhattan and San Francisco. Symptoms may not develop for three years or more after a person has been infected with the AIDS virus. There will be many more cases among heterosexuals and among recipients of blood transfusions who became infected before the disease was identified. People who have no symptoms may carry and transmit the virus. We do not know how many of those people will eventually develop AIDS, or whether some of them will continue to have the virus and not the disease. Anyone who has been exposed to the virus is at risk, and the probability of rapid spread of the virus increases with the size of the pool of infected people.

There are many questions about AIDS that have not yet been answered. Where did this very virulent virus come from? (It appears to have arisen in Africa, perhaps among monkeys.) How did it become a human disease? Was it sudden? How did it reach the United States? Will everybody who becomes infected with the virus get the disease? Do people who develop AIDS already have a mild immunodeficiency that makes them susceptible to this more serious disease? Is the likelihood of developing the disease related to the number of AIDS viruses infecting the individual? In nearly all other diseases, the probability of developing the disease is directly related to the number of organisms infecting the person.

Even though there are many unanswered questions about AIDS, researchers at the Centers for Disease Control feel confident in making the following recommendations about prevention:

> To be safe from risk of exposure to HTLV-III infection, persons should avoid any sexual activity that involves the exchange of body fluids, such as semen, with an individual who is known or suspected to be infected.
>
> For uninfected individuals likely to continue sexual exposure to HTLV-III, such preventive measures as condoms, diaphragms, or spermicides offer some theoretical protection, but their efficacy is unproved.
>
> The Public Health Service has recommended that women with . . . evidence of infection with HTLV-III should postpone or avoid pregnancy to prevent transmission to the fetus or newborn. Women who may have been exposed should have a blood test for HTLV-III before considering pregnancy. Premarital and prenatal screening for antibody to HTLV-III should be seriously considered by physicians or clinics providing care for women in populations with increased risk of infection, such as intravenous drug users.
>
> In addition, donors of organs, tissue, or sperm should be serologically tested for HTLV-III to prevent transmission. (From *Science* 229(4720):1352, 1985.)

In October 1986 the Surgeon General of the United States, Dr. C. Everett Koop, issued a report to the American people about AIDS. He stressed the seriousness of the AIDS epidemic for the entire population, not only the high risk groups. He recommended that all people begin to practice "safe sex," that is, the use of condoms and a limitation on the number of sexual partners. Dr. Koop also recommended that sex education classes begin as early as third grade and continue through high school as part of the battle against AIDS.

The rise of AIDS as a major public health problem raises many questions about public policy. There are no easy answers to such questions. Public education is essential so that important decisions are not based on misinformation, fear, and prejudice. You will discuss the implications of one AIDS-related policy decision in part B of investigation 11.3.

Some other questions for you to think about include:

Should a child with AIDS be allowed to attend school with other children? Why or why not?

The brother of your best friend has AIDS. Should you stop visiting your friend? Why?

Can you get AIDS by donating blood? Why?

Which do you think is more important, finding a drug to cure AIDS or developing a vaccine to prevent AIDS? Why?

Supplemental Investigations

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Investigation TRB.1 RELATIONSHIPS BETWEEN A PLANT AND AN ANIMAL

Introduction

In this investigation you will study a segment of the carbon cycle by setting up closed systems with plants and animals. You will test for the presence of CO_2 using a dye. The dye is an indicator that changes color when a chemical reaction you ordinarily cannot see has taken place. Bromthymol blue is the indicator dye; it becomes green or yellow in the presence of an acid. CO_2 forms a weak acid when dissolved in water. Therefore, in this investigation bromthymol blue is used to indicate, indirectly, the presence of CO_2.

Materials (per team)

8 screw-cap culture tubes, 20 mm × 150 mm
glass-marking pencil
2 test tube racks
4 small water snails
4 pieces of elodea
bromthymol blue solution
container of melted paraffin
about 150 ml dechlorinated tap water
light source
box, large enough to cover 4 test tubes
small brush
white paper or white card

Procedure

1. Read through the whole procedure. Then state the hypothesis that you think the procedure seems designed to test.
2. Prepare 2 sets of 4 culture tubes each, and label them A1, A2, A3, A4, and B1, B2, B3, and B4.
3. Pour dechlorinated water into each tube to approximately 20 mm from the top. (Tap water becomes dechlorinated on standing for 24 hours: the chlorine in the water escapes into the air.)
4. To every tube except A1 and B1, add 3 to 5 drops of bromthymol blue solution. Add nothing more to tubes A1 and B1.
5. To tubes A2 and B2 add a snail; to tubes A3 and B3 add a leafy stem of elodea; and to tubes A4 and B4 add both a snail and a leafy stem of elodea (see figure TRB.1–1).

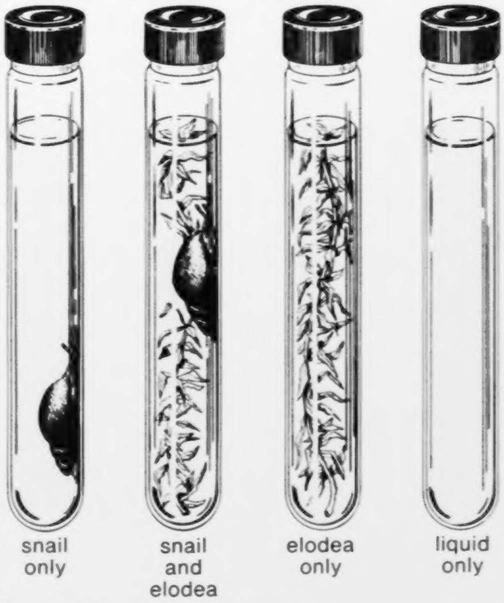


Figure TRB.1–1 Experimental setup.

6. Place a cap on each tube and tighten it. Brush melted paraffin onto the capped end of each tube to seal it. After the paraffin cools, test the seal by turning the tubes upside down for about 5 minutes.
7. When all tubes are watertight, place one set (A1 to A4) in strong artificial light. Place the second set (B1 to B4) in a box where it can be kept in the dark.
8. After 24 hours, observe both sets of tubes. Place a white card or sheet of white paper behind the tubes, so that it will be easier to determine color. In your data book, record the changes in color of the indicator and the condition of the organisms. Record the letter and number of each tube you have observed.
9. Place the A series in the dark, and the B series in the light.
10. After another 24 hours have passed, repeat your observations.
11. Swtich the A series back to light and B back to dark. After several days observe the tubes again.

Discussion

1. In which tube did the organism die first?
2. Snails and elodea usually live well in an aquarium or pond. We might, therefore, hypothesize that being cut off from air had something to do with their deaths. What substance in the air may have been needed?
3. Another possibility is that death may have resulted from the accumulation of a poisonous material in the water. What does the indicator show?
4. Recall what you have read about photosynthesis and the carbon cycle. Use this information and your answers to the previous questions to explain your data.
5. Why do you think tubes A1 and B1 were used in this investigation even though no organisms were placed in them?
6. Did the indicator change color in tubes A1 and B1? If so, how might you explain this?
7. What results might you expect if all the tubes were kept in total darkness?
8. Do the data support your hypothesis? Explain.
9. If not, try to devise a hypothesis that is consistent with all your observations.

Investigation TRB.1 RELATIONSHIPS BETWEEN A PLANT AND AN ANIMAL

You may want to have a small team in each class set up the tubes. Tubes from all classes then can serve as duplicates.

If your classes have had little or no previous science, you might demonstrate the properties of oxygen and cabon dioxide. Directions for doing this are found in any high school chemistry manual, but avoid becoming too deeply involved in the chemistry. A brief demonstration of the effect of exhaled air on bromthymol blue also is desirable.

Some of the snails will die during this experiment. Be prepared to explain the necessity of using living animals in some investigations.

Materials

If screw-cap culture tubes are not available, substitute standard test tubes (18 mm × 50 mm), 4-oz. prescription bottles, or 4-oz screw-cap specimen jars. Sealing the tubes is not required if containers do not leak when inverted. If sealing the tubes is necessary, melt paraffin or a soft wax candle, such as a plumber's candle, in a beaker on a hot plate.

You can purchase elodea and small snails wherever aquarium supplies are sold. If you use very small snails, use smaller containers than suggested or more snails per container. The snails must produce enough CO_2 to cause an indicator change. You may want to substitute local aquatic plants for the elodea.

Dechlorinated tap water is recommended rather than pond water because it is becoming increasingly difficult to find uncontaminated pond water. If chlorine is not added to your water supply, you can use your tap water without treatment. There are two simple ways to dechlorinate water: put it in an open container with a large surface area and let it stand overnight, or add a commercial dechlorinating agent, as directed on the bottle. Dechlorinating agents, sometimes called chlorine neutralizers, are available wherever aquarium supplies are sold.

Bromthymol blue has a narrow pH range: pH 6.0 (yellow) to pH 7.6 (blue). Adjust the number of drops used to give each container a light blue tint. A color-matching blank (container with water and indicator only) may be useful. Prepare a 0.1% stock solution by dissolving 0.5 g bromthymol blue powder in 500 ml distilled water. To the stock solution add, drop by drop, a very dilute solution of ammonium hydroxide until the solution turns blue. If the water in your community is alkaline, you may not need to add ammonium hydroxide. (Note: Solutions of bromthymol blue purchased from supply houses usually contain alcohol, which will kill organisms.)

It will be worthwhile to try this investigation ahead of time. You can adjust the amounts of plants and animals as well as the amount of indicator necessary to give clear results. To avoid excessive heat, place setups away from incandescent lights or use fluorescent light with a growth-type bulb.

Discussion

In light a green plant appears to play a role in the exchange of CO_2 and O_2 opposite to that of animals:

$$CO_2 + H_2O \underset{\text{respiration}}{\overset{\text{photosynthesis}}{\rightleftharpoons}} (CH_2O)_x + O_2$$

Respiration, of course, goes on continuously in both green plants and animals. In light, green plants almost immediately reuse (in photosynthesis) the CO_2 released in respiration, so it does not accumulate in the environment. In darkness, however, when photosynthesis does not occur, released CO_2 does accumulate. Therefore, in darkness, bromthymol blue turns green in a culture tube containing elodea, because CO_2 from respiration is accumulating in the water, acidifying it. When, on exposure to light, photosynthesis begins again, CO_2 is used more rapidly than it is released, and the plant starts to extract CO_2 from the water. As the amount of CO_2 in the water decreases, the indicator changes to blue.

So much for the theory of the experiment. In actuality, many strange things may happen; explaining these may test the ingenuity of teacher and students. For example, tube A4 may be green or yellow at the top and blue at the bottom. (In this case, the snail is usually found at the top of the tube and the elodea at the bottom.)

Investigation TRB.2 RELATIONSHIPS BETWEEN TWO KINDS OF PLANTS

Introduction

Many unusual ecological relationships occur in communities that have been formed by humans. Plants that would never occur together naturally often are found together in gardens and cultivated fields. To farm or garden successfully, it is important to understand the relationships among such plants.

In this investigation you can examine the relationships between two kinds of plants during the early stages of growth. Read the procedure. Then form a hypothesis about the growth of radish and tomato seedlings.

Materials (per team)

3 plastic or wooden boxes, at least 30 × 20 × 10 cm
sterile soil or potting soil to fill the 3 boxes
trowel
wood block, about 4 × 8 × 8 cm
sharp pointed stick (or pencil)
about 450 tomato seeds
about 450 radish seeds
3 pieces sheet glass or clear plastic wrap a little larger than the area of the boxes
beaker, 1000 ml
paper towels
balance

Procedure

1. Place the soil in the boxes and smooth to form a level surface. Use a block of wood to press the soil down firmly, but do not pack it tightly. If necessary, add soil to obtain a firmed depth of at least 7 cm.
2. Label the boxes A, B, and C. Sprinkle the soil with water and allow the water to soak in.
3. Using the pointed stick or pencil, draw furrows on the surface of the soil parallel to the long side of each box. Make them about 0.5 cm deep and 5 cm apart.
4. In box A place tomato seeds 1 cm apart in each furrow. In box B place radish seeds 1 cm apart. In box C place tomato and radish seeds alternately 1 cm apart. Each box should contain the same number of seeds. Record this number for each box. Use the wooden block to firm the seeds into the soil. By doing this, you will barely cover the seeds with soil.
5. To reduce evaporation, cover each box with a sheet of glass or clear plastic wrap. Put all the boxes where they will receive strong light but even temperature.
6. Observe the boxes from day to day. Remove the glass or plastic before any seedlings press against it. By this time the seedlings may be gently sprinkled with water without being disturbed. Keep all boxes equally moist. If they are kept on a windowsill, turn them daily so that seedlings on each side will receive about the same amount of light.
7. When the plants are 8 to 15 cm high, harvest them without mixing the plants from the 3 boxes. To do this gently pull all the tomato plants in box A. Rinse the soil from the roots and dry the plants on paper towels. Do the same with the radish plants from box B. Remove, wash, and dry the tomato plants in box C separately from the radish plants.
8. Count and determine the mass of all the plants together from box A. Then repeat for all the plants from box B. Do the same with all the *tomato* plants from box C, and then with all the *radish* plants from box C.
9. There were only half as many radish seeds and tomato seeds in box C as in boxes A and B. So before you compare masses of tomato plants and radish plants, divide the A and B masses by 2.

Discussion

1. Organize your data in the form of a bar graph, with masses on the vertical axis. Arrange the 4 bars along the horizontal axis, left to right, in the order in which you obtained the masses.
2. Is there a difference between the total mass of the tomato plants grown in box A (divided by 2) and the total mass of those grown in box C? If so, how do you account for the difference?

3. Is there any difference between the total mass of the radish plants grown in box B (divided by 2) and the total mass of those grown in box C? If so, how do you account for the difference?
4. If you found a difference in mass, do you think growing tomatoes and radishes together has more effect on the tomatoes or on the radishes? Or are the effects equal?
5. Try to explain how any effect you noted may have occurred.
6. What term would you apply to the relationship between tomatoes and radishes shown in this experiment?
7. Did every seed germinate? If some did not, how could you correct your data for differences in germination?

Each experiment must have a control. The control represents the normal situation and is used for comparison. When we test a hypothesis, we compare the results of the control to the results of the varied situation (the variable).

8. Which 2 of the 3 boxes of plants in this investigation were the controls?
9. Why are there 2 control boxes?

Investigation TRB.2 RELATIONSHIPS BETWEEN TWO KINDS OF PLANTS

If you have the space, allow every team in each class to set up this investigation. Students usually like to grow their own plants. Keep in mind that growing time will be 25 to 35 days, depending on your growing conditions. As an alternative, a team in each class could conduct this experiment for the class and report the results. A period should be used to record, graph, and analyze the results.

Materials

You may want to purchase sterilized potting soil to eliminate the need for oven sterilization. Seedlings will be easier to remove from potting soil. If you oven sterilize, do the following: Prepare the soil by removing stones and breaking all lumps. Place the soil in pans and bake it in an oven at 300° F for 1 hour or more.

Radish and tomato seeds work well, but other plants can be substituted (e.g., turnip and pepper, or pea and muskmelon). Fairly rapid germination in high percentage is necessary, so use fresh seeds. Beans disturb their neighbors in emerging from the soil—but this could be considered a competitive factor. Cardboard boxes can be used if lined with metal foil or plastic sheeting.

Procedure

The students may have to loosen the soil around the tomato plants to enable them to pull out the entire root system.

Discussion

2–4. These questions follow directly from whatever data are obtained.

5. If differences are found between the pure cultures of either species and the mixed cultures, these differences can perhaps most readily be explained on the basis of more effective absorption of water or nutrients by one species than by the other when the two are in competition with each other. At later stages, one species may overtop the other and thus reduce its supply of radiant energy.

6. Most students recognize that the factor explored in this investigation is competition.

7. The percentage of seeds germinating will vary with age and other factors. There may be a difference between the tomato and radish seeds, but there should be no significant difference between seeds from the same batch in different boxes.

8. The definitive assessment of competition must rest on its effect on the populations of the two species. Since these species do not reproduce vegetatively, the effect depends on the quantity and viability of the seeds produced. Any conclusions based on the results of this experiment depend on the assumption that the size of a plant, as indicated by mass, is related to its ability to produce viable seeds. Some students may want to investigate intraspecific competition, though it is more closely related to the idea of crowding than to community study. Use a single kind of seed, but vary the distance between seeds in each of several flats. Effects of spacing can be correlated with the quantity of seeds produced.

9,10. The control boxes are those with only tomatoes or radishes in them. They were both needed to determine what the normal growth of these plants was without the effects of interspecific competition.

Investigation TRB.3 ENVIRONMENT AND NATALITY

Introduction

Brine shrimp are small aquatic animals that live in such places as the Great Salt Lake, Utah. Unlike the eggs of most other aquatic animals, those of brine shrimp can survive drying. Indeed, the dried eggs may still hatch after a year or more. This fact has made the eggs useful to tropical fish fans, for the eggs can be kept easily until needed, then hatched and used as food.

A number of environmental factors influence the hatching rate (natality) of brine shrimp eggs. Read the following procedure. Then state one or more hypotheses concerning the relationship of environmental factors to brine shrimp natality.

Materials (per team)

glass-marking pencil
6 petri dishes
graduated cylinder
10 ml distilled (or deionized) water
sodium chloride solutions (1%, 2%, 4%, 8%, 16%), 10 ml each
volume measure (dropping pipet with mark 3 mm from tip)
brine shrimp eggs
refrigerator
incubator
stereomicroscope
dropping pipet

Procedure

1. Using a glass-marking pencil, number 6 petri dishes on the sides of the bottom halves. Place your team symbol on each dish. Mark a large cross on the bottom of each dish to divide it into 4 quarters. Number the quarters from 1 through 4.
2. Pour 10 ml of distilled (or deionized) water into dish 1.
3. Into dish 2, pour 10 ml of 1% sodium chloride (salt) solution.
4. Into dishes 3 through 6, pour 10 ml of 2%, 4%, 8%, and 16% sodium chloride solution, respectively.
5. Using the volume measure, measure dry brine shrimp eggs as directed by your teacher. Scatter them on the surface of the water in dish 1. Scatter the same volume in each of the other dishes.
6. Cover each of the dishes and stack them in the place designated by your teacher. Some teams' dishes will be placed in a refrigerator and some in an incubator at a temperature 10 to 15° C above room temperature; others will remain at room temperature.
7. Check the temperature at the place where your dishes are to be kept and record it in your data book.
8. Recheck and record the temperatures on each of the following 2 days.
9. Two days after setting up the cultures, use a stereomicroscope to count the hatchlings in each dish. You may find that a rough count will be satisfactory. Or you may use a dropping pipet to remove each young brine shrimp as it is counted. The cross on the bottom of the dish will help you to be sure you check the entire dish. Record each number (indicating whether it is an estimate or a count) in your data book.

Discussion

1. Assemble data from all the teams on the chalkboard. For each of the 3 temperature conditions, total the data for each of the 6 petri dishes. Then calculate an average for each dish. Set up a graph with the number of individuals on the vertical axis and salt concentrations on the horizontal axis. Use O's to plot the points for the low-temperature dishes. Use X's for the room-temperature dishes, and +'s for the high-temperature dishes. Connect the O's with 1 line, the X's with a 2nd line, and the +'s with a 3rd line.
2. What conclusion can you make about the effect of temperature on brine shrimp natality?
3. What conclusion can you make about the effect of salt percentage on brine shrimp natality?
4. Do your data indicate any interaction of temperature and salt percentages?

Investigation TRB.3 ENVIRONMENT AND NATALITY

This investigation provides you with a good opportunity to notice students who need help with laboratory skills as you observe their work.

Prepare 2 sets of dishes per temperature for each class to generate enough data for analysis.

Materials

Syracuse watch glasses are rather small, and ordinary culture dishes are rather large for use in this investigation; but either may be substituted for petri dishes, if necessary. Adjust the amounts of the solutions accordingly.

All solutions should be made with distilled or deionized water unless you have a good source of low-mineral spring water. A team of careful students can make the solutions for all classes. The percentages are by weight, 1 ml of water being equal to 1 g. Thus the 16% solution can be made by dissolving 160 g sodium chloride in 840 ml water. Make the remaining solutions by serially diluting 1 part of each successive solution with 1 part water. For example, 100 ml 16% plus 100 ml water will give you 200 ml of 8%. **CAUTION:** *Avoid household iodized NaCl, but C.P.-grade laboratory NaCl is not necessary.* Brine-shrimp eggs can be obtained from most pet shops as well as from biological supply houses. New eggs should be purchased each year to ensure successful hatching. If hatching does not occur, it most likely results from nonviable eggs.

A student team also can prepare the volume measures. Have them carefully mark dropping pipets 3 mm from the tip with a file line. The important thing here is that the same volume of eggs be added to each dish in the class. The volume of eggs also must be small enough that all hatchlings can be counted. The wetted head of a small pin or the wetted tip of a pencil also can be used as a measure for the eggs.

A 10× hand lens can be used in place of a stereomicroscope, but it is more tedious to use.

Discussion

Average the data from all teams. In collecting the data on a chalkboard (or on an overhead projector), you need a form with 18 columns—6 for each of the 3 temperature conditions. If some students are still having trouble graphing, you might have them make a bar graph.

The major new element in this investigation is the consideration of 2 variables simultaneously. The graphing procedure separates the 2 for study. In general, warmer temperatures increase the hatch, as does higher salt concentration, but both may be so high as to inhibit hatching. This may occur if temperature approaches 45° C, and it may show up in the 16% salt concentration. If you wish, you can use such results to anticipate the idea of optimum environment.

Data do not always clearly indicate interaction of factors. The best place to look for this is in the 4% and 8% salt concentrations, where a decided difference between low and medium temperatures is likely to appear.

Investigation TRB.4 HUMAN INHERITANCE

Introduction

This investigation provides some facts. You are asked to answer questions based on those facts. The answers to one set of questions leads to a new set of facts. So it is necessary to move step by step through the procedure.

Procedure

Part A—Percentages of Male and Female Infants

With respect to the sex chromosomes, females can be designated as XX, and males XY.

1. Considering only the sex chromosomes, how many kinds of gametes can females produce?
2. How many kinds of gametes can males produce?

   The frequency of any characteristic within a group is expressed as a fraction. Thus, in a group of 100 marbles containing 20 red and 80 blue marbles, the frequency of red marbles is 20/100, or 1/5, or 20% or 0.2. The frequency of blue marbles is 80/100, or 4/5, or 80%, or 0.8. The 2 frequencies are represented by the letters p and q. Thus, for any group of red (R) and blue (B) marbles, frequencies of the 2 kinds may be written as $pR + qB$.

   Any population of sperm is represented by the mathematical expression $pX + qY$.
3. Using your knowledge of meiosis, what are the values of p and q?

   The same kind of mathematical expression may be used to represent the population of eggs produced by a female.
4. What are the values of p and q for the egg population?

   The frequencies of males and females among human offspring may be predicted in the same way you predicted the percentages of heads and tails when tossing coins.

   $$\begin{array}{ccccc} \text{sperm} & & \text{eggs} & & \text{zygotes} \\ (pX + qY) & \times & (pX + qY) & = & ? \end{array}$$
5. Calculate the expected frequencies of the zygotes.

   On the basis of your results, you might predict that equal numbers of male and female infants would be born. This expectation is based on 2 assumptions: (a) that X-carrying and Y-carring sperm have equal chances of reaching and fertilizing an egg, and (b) that XX and XY zygotes have equal chances of developing to birth stage. The 2 assumption seem natural, and they are commonly made. However, available data do not support your prediction. Data on deaths of embryos and on deaths during birth show that males have a much poorer chance of developing and surviving birth than do females.
6. In the light of these data which assumption must you reject?
7. If you still accept the other assumption, how must the expected percentages of male and female infants be changed?
8. Data on live births show that for every 100 females born, about 105 males are born. What do these data suggest about the other assumption?

Part B—Inheritance of Hemophilia

Hemophilia is a condition in which normal blood clotting does not occur. It is an x-linked trait.

Figure TRB.4–1 shows, in part, the occurrence of hemophilia among the royal families of Europe during the 19th and 20th centuries.

1. List the mothers who must have been carriers—that is, heterozygous.

   The chart shows the actual occurrence of hemophilia in a pedigree. Now consider the frequencies (expressed in percentages) of hemophiliacs—persons afflicted with hemophilia—that we may *expect* among the offspring of certain marriages.

   First, consider the marriage of a hemophiliac man and a woman homozygous for normal blood clotting.
2. What percentage of their male offspring do you expect to be hemophiliacs?

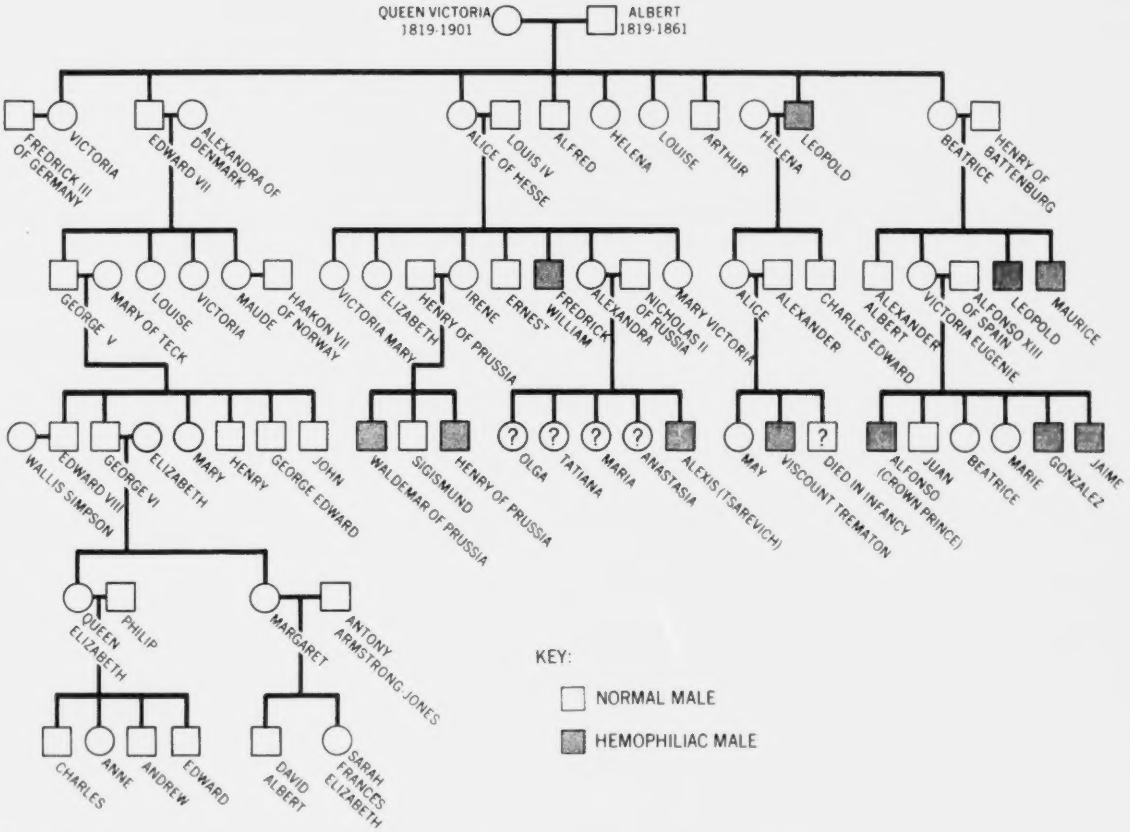

QUEEN VICTORIA 1819-1901
ALBERT 1819-1861
FREDRICK III OF GERMANY
VICTORIA
EDWARD VII
ALEXANDRA OF DENMARK
ALICE OF HESSE
LOUIS IV
ALFRED
HELENA
LOUISE
ARTHUR
HELENA
LEOPOLD
BEATRICE
HENRY OF BATTENBURG
GEORGE V
MARY OF TECK
LOUISE
VICTORIA
MAUDE
HAAKON VII OF NORWAY
VICTORIA MARY
ELIZABETH
HENRY OF PRUSSIA
IRENE
ERNEST
FREDRICK WILLIAM
ALEXANDRA
NICHOLAS II OF RUSSIA
MARY VICTORIA
ALICE
ALEXANDER
CHARLES EDWARD
ALEXANDER ALBERT
VICTORIA EUGENIE
ALFONSO XIII OF SPAIN
LEOPOLD
MAURICE
WALLIS SIMPSON
EDWARD VIII
GEORGE VI
ELIZABETH
MARY
HENRY
GEORGE EDWARD
JOHN
WALDEMAR OF PRUSSIA
SIGISMUND
HENRY OF PRUSSIA
OLGA
TATIANA
MARIA
ANASTASIA
ALEXIS (TSAREVICH)
MAY
VISCOUNT TREMATON
DIED IN INFANCY
ALFONSO (CROWN PRINCE)
JUAN
BEATRICE
MARIE
GONZALEZ
JAIME
QUEEN ELIZABETH
PHILIP
MARGARET
ANTONY ARMSTRONG-JONES
CHARLES
ANNE
ANDREW
EDWARD
DAVID ALBERT
SARAH FRANCES ELIZABETH
KEY:
NORMAL MALE
HEMOPHILIAC MALE

Figure TRB.4–1 Inheritance of hemophilia in descendants of Queen Victoria of England.

3. What percentage of the female offspring do you expect to be hemophiliacs?
4. What percentage of females do you expect to be carriers?

Second, consider the marriage of a man whose blood clots normally and a woman who is a carrier of hemophilia.

5. What percentage of their male offspring do you expect to be hemophiliacs?
6. What percentage of their female offspring do you expect to be hemophiliacs?
7. What percentage do you expect to be carriers?

Investigation TRB.4 HUMAN INHERITANCE

This investigation can be assigned for out-of-class work to students who read and reason well.

Procedure

Part A

1. One (100% X-bearing).
2. Two (50% X- and 50% Y-bearing).
3. 50% and 50%, or 0.5 and 0.5.
4. 100% X and 0% Y.
5. $(0.5\ X + 0.5\ Y) \times (1.00\ X + 0\ Y) = 0.5\ XX + 0.5\ XY$.
6. Assumption B must be rejected.
7. If more males than females die as embryos, then one should expect more females than males among newborn babies.
8. More XY zygotes must be formed than XX zygotes; therefore, a Y-bearing sperm must have a greater chance of fertilizing an egg than an X-bearing one.

Part B

1. Victoria, Alice of Hesse, Beatrice, Irene, Alexandra, Alice, and Victoria Eugenie.
2. 0%.
3. 0%.
4. 100%.
5. 50%.
6. 0%.
7. 50%.

Investigation TRB.5 SICKLE CELLS AND EVOLUTION

Introduction

The modern human species has developed during 40 to 60 thousand years or more. Biologists assume that most variations within the species have some survival value, but could this include even variations that cause diseases?

Sickle-cell anemia is a disorder in which the hemoglobin inside the red blood cells aggregates, or clumps, when the oxygen supply is low. As a result, the cells lose their flexibility and assume an abnormal, or sickle-like, shape. If enough of these cells block small blood vessels and stop the flow of nutrients and oxygen, vital organs can be damaged and the patient might die.

Could a blood disease such as sickle-cell anemia have survival value? If so, under what circumstances could this disease be an advantage to people?

Procedure

The Hb^S gene brings about the formation of hemoglobin associated with sickle-cell anemia. It is rare in most human populations. In some parts of Africa, however, the sickle-cell trait (genotype Hb^AHb^S) is found in as much as 40% (0.4) of the population.

1. In such a population, what is the probability that any 2 heterozygous individuals will marry?
2. What percentage of their offspring may be expected to be homozygous for the sickle-cell gene?
3. On the average, then, which would you expect to produce more offspring—individuals with the sickle-cell trait or individuals with normal red blood cells?
4. How many sickle-cell genes are lost from the gene pool when a child with sickle-cell anemia dies?
5. What effect would you expect the death of children with sickle-cell anemia to have on the frequency of the sickle-cell gene in any population?

   You have described an evolutionary change in terms of modern genetics.

6. How would Darwin have described this situation? Actually, there is no evidence that the frequency of the gene for sickle-cell is becoming less in the African population. Therefore, a biological problem arises. How can the frequency of the gene for sickle-cell be maintained at such a high level when selection works so strongly against the gene?

   You know that a scientist begins an attack on such a problem by devising hypotheses. These are explanations that can be tested by making observations or carrying out experiments. Biologists have developed at least 3 hypotheses to account for the high frequency of the sickle-cell gene in African populations. The 1st is based on mutation rates. A 2nd is based on fertility and a 3rd on resistance to disease.

7. Using these clues, devise 3 hypotheses to explain the persistently high frequency of the sickle-cell gene in African populations. *Write these down before reading further.*

   The rate at which sickle-cell genes are lost from the gene pool is about 100 times the average mutation rate of gene Hb^A to Hb^S. In addition, geographically, mutation rates vary only slightly.

8. Does this information support or weaken your 1st hypothesis? Explain your answer.

   At present there is no evidence that individuals with the sickle-cell trait produce more children than do those with normal red blood cells.

9. Does this information support or weaken your 2nd hypothesis? Explain your answer.

   As data on sickle-cell anemia were collected, the frequencies of the sickle-cell trait in various populations were plotted on maps. It became clear that the gene is most common in a belt extending across central Africa. In the same region malaria and hookworm disease are common. Consider your knowledge of these 2 diseases and of the part of the body affected by sickle-cell anemia.

10. Which of the 2 diseases, if either, would you think more likely to be associated with sickle-cell anemia? The foregoing question—and its answer—provides new information for your 3rd hypothesis.

11. How might you now word that hypothesis?

To test that hypothesis, an investigator examined the blood of 209 children of an East African population. Both malaria and sickle-cell anemia were common in this population. The results are given in the table below.

	With Malaria	Without Malaria	Total
SC's	12	631	43
NSC's	113	134	247
Total	125	165	290

12. Calculate the percentage of *SC*'s (persons with either the sickle-cell trait or sickle-cell anemia) who also have malaria. Find the percentage of *NSC*'s (persons without the trait or anemia) who have malaria.

About 22% of the ancestors of American blacks had sickle-cell trait or anemia.

13. Would genetic mixture of American blacks with the population of European ancestry and with the American Indian population have caused this frequency to increase, to decrease, or to remain the same?

In the United States, humans have almost completely eliminated the vector of malaria, the *Anopheles* mosquito.

14. Do heterozygotes of sickle-cell still have a survival advantage over homozygotes in this country? Recall that an individual homozygous for sickle-cell often dies before reaching reproductive age.
15. What might you predict would happen to the frequency of the HB^S gene in the United States?

Discussion

1. How does sickle-cell illustrate the factors in the evolutionary process?
2. How does this investigation show that evolution involves interaction between the genetic makeup of an organism and its environment?
3. Hereditary traits (and the genes that determine them) are sometimes described as beneficial or good and harmful or bad. Keeping in mind the ideas in this investigation, comment on the use of such terms.

TEACHER'S ANNOTATIONS

Investigation TRB.5 SICKLE CELLS AND EVOLUTION

This investigation uses a Socratic technique, so it is inevitable that answers to some questions are given or implied at a later point in the development. To obtain the most value from the investigation, work through it point by point. The aim is not to get correct, neatly written answers to all the questions; the aim is to see how the reasoning proceeds.

Procedure

Perhaps your students will be able to work through the investigation independently. Class discussion then can center on points of controversy or confusion. In most cases, however, you probably will want to work step by step with the class. If you do this, stop after item 6 and resume discussion the following day. This provides students with an opportunity to formulate hypotheses for item 7. Even if they read on and find out which way the hypotheses should point, they will have some experience in wording them.

1. If marriage is random with respect to this trait, 16% (0.16).
2. 25%.
3. Because many offspring with sickle-cell anemia die in childhood, parents who produce children with sickle-cell anemia should have fewer surviving offspring unless, on the average, they have more children than other parents.
4. 2.
5. It should reduce the frequency of the sickle-cell gene.
6. Darwin, of course, would have said nothing about gene frequencies but would have stated the matter in terms of the natural selection of individuals.
8. Any hypothesis for item 7 must depend on a mutation rate toward sickle-cell anemia that equals the rate of elimination by natural selection. Therefore the hypothesis is weakened by this information.
9. The information neither supports nor weakens a hypothesis based on differential fertility: it is negative evidence. The tendency is to assume no difference in the absence of contrary evidence.
10. Because the malaria parasite lives in red blood cells at one point in its cycle, it has a close association with them and with hemoglobin. Hookworms are not discussed specifically in the text, but students should suspect that the connection of hookworms with hemoglobin is less intimate than that of *Plasmodium*.
11. The wording might be: The frequency of the sickle-cell gene does not decline, because persons who carry it have a greater resistance to malaria and therefore have greater survival than homozygous normal individuals.
12. *SC*'s with malaria: $\frac{12}{43}$ or 28%.
13. Students may have been impressed with the Hardy-Weinberg principle and answer no. This situation is different. There the original frequency was calculated on the basis of both original populations. Here the 22% applies to only one of the original populations. The frequency of the sickle-cell gene in the American Indian and European populations was presumably close to 0, so combining the 3 populations gives a new and lower average frequency of the gene. It does not, however, decrease the number of such genes, which depends on the number of individuals bearing them. This can be reduced only if some factor reduces the number of individuals that bear the genes relative to the number that do not.

Discussion

1. The main point here is that natural selection operates to eliminate homozygotes (through defective physiology) and to conserve heterozygotes (through protection against the debilitating effects of a parasite).
2. Lack of malarial parasites in the environment tends to change the frequency of the sickle-cell gene from the frequency than can exist in an environment where the parasites are abundant.
3. With respect to oxygen supply, the sickle-cell gene certainly is harmful. But when malaria is a factor in the environment, the sickle-cell gene in the heterozygous state is an advantage to survival. When malaria is not a factor in the environment, the gene is a detriment to survival. Thus "harmful" and the other terms are relative (to the environment) rather than absolute terms. The terms also vary between homozygous and heterozygous states. The hybrid has an advantage that neither homozygote has.

Investigation TRB.6 A GARDEN OF MICROORGANISMS

Introduction

Where do microorganisms grow? This investigation will give you an opportunity to discover some of the places, and also introduce you to many different kinds of microorganisms.

Materials (per team)

very ripe fruit
hay or dried grass
dried beans
cream cheese
stale bread
cornstarch
peppercorns
pond or river water with some bottom materials
rich garden soil
8 finger bowls
2 or 3 glass covers for finger bowls
glass-marking pencil
filter paper
spatula

(per pair of students)
hand lens of stereomicroscrope
monocular microscope
forceps
2 dissecting needles
microscope slide
dropping pipet
coverslip

Procedure

1. Mark each finger bowl with your team symbol and number the bowls 1 through 8.
2. Place materials in the bowls as follows:
   Bowl 1—Fruit, cut to fit into the bowl.
   Bowl 2—Water from a pond or river, containing bottom materials.
   Bowl 3—Enough hay to cover the bottom of the bowl and 200 ml tap water.
   Bowl 4—A few dried beans and 200 ml tap water.
   Bowl 5—Cream cheese, spread over the bottom of the bowl about 1 cm deep.
   Bowl 6—Two pieces of stale bread, moistened (not soaked) with tap water. Expose to air for 24 hours, then cover.
   Bowl 7—Place a piece of filter paper on the bottom of the bowl. Mix 5 g cornstarch with 95 g rich garden soil. While mixing soil and starch, add enough water to give the mixture a doughlike consistency. Spread the mixture smoothly on the filter paper, using a spatula. Keep the soil mixture moist throughout the investigation.
   Bowl 8—1 g peppercorns and 200 ml tap water.
3. Place the bowls in stacks of 3 or 4 and cover each stack with a piece of glass or an empty bowl. Do not place in direct sunlight. If any of the bowls fit very tightly together, place the flat end of a toothpick between them.
4. Examine the bowls each day. In your data book, record the following: (a) date of observation; (b) number of bowl; (c) macroscopic appearance of bowl's contents; (d) appearance under a hand lens or stereomicroscope; (e) anything else that you can notice with any of your senses.
   In describing organisms, consider color first, then size. Some of the following descriptive terms may be useful: fuzzy, cottony, powdery, smooth, rough, shiny, glistening, dull, compact, spreading, irregular. You should not, of course, limit yourself to these terms.
5. Afer good growth has been obtained, make observations with a monocular microscope. For a solid medium, use forceps to transfer bits of the visible growth to a clean slide. For a liquid medium, draw up a drop or two with a dropping pipet and place on a slide. Then, for either kind of preparation, add a coverslip.
6. Record your observations by making sketches. Attempt to place organisms in taxonomic groups using references provided by your teacher and appendix 3, A Catalog of Living Things.

Discussion

1. Did you find any evidence that different groups of organisms grow better on one or another kind of food? If so, what is it?
2. What group of organisms did you find growing in the largest number of dishes?
3. What happens to the food materials as the organisms grow? Explain.

For Further Investigation

1. You have seen what microorganisms do to their food substances, some of which also are foods for humans. Clearly, it is desirable for us to try to prevent such effects. Chemicals often are added to human foods to discourage introduction and growth of microorganisms. Commercial bread and catsup usually contain such chemicals. These must be mentioned on the label of the product. By comparing the growth of microorganisms on homemade bread and catsup with growth on the commercial products, you can test the effectiveness of such chemicals.
2. Choose one food and investigate the growth of microorganisms on it at various temperatures.

Investigation TRB.6 A GARDEN OF MICROORGANISMS

The organisms that appear in the cultures may belong to any kingdom. Bacteria and fungi will be most abundant, but protists and animals also may appear. Microbiologists have seldom been much concerned about distinctions among kingdoms. This again emphasizes the difficulties of reconciling convenience and kinship in classification. Just be sure your students do not equate microbe with protist.

Materials

You may substitute glass or plastic containers for finger bowls. These should be more than 10 cm in diameter and have more or less vertical sides at least 4 cm high. Small plastic refrigerator dishes are good; but unless they have covers, they cannot be stacked and so require more space. All the containers used in any one class should be alike.

The recommended media have been chosen with an eye to culturing a wide variety of microorganisms; there are, of course, many other possible choices. If necessary, the number per team may be reduced, but the media recommended for bowls 1, 2, 3, 4, and 7 should be retained. For bowl 7, be sure to have garden soil rather than packaged commercial soil. The fruit for bowl 1 can be different for each team; so can the kind of water for bowl 2. You may wish to concentrate some organisms found in pond, river, or lake water by using a plankton or small aquarium net. Peppercorns (bowl 8) are recommended because of their association with Leeuwenhoek's work. Students can supply most of the materials for the bowls.

If possible, use stereomicroscopes rather than hand lenses.

Tap water can be used in setting up the cultures (except for bowl 2); but if the water contains much chlorine, let it stand in a shallow container for 24 to 48 hours. Distilled or deionized water is better.

Procedure

It is convenient to set up teams of 8 students each. Each student is responsible for one of the bowls.

All bowls must be clean and free of all soap or detergent at the outset. After washing the bowls, rinse them thoroughly at least 4 times.

If the bowls are set up on a Friday, they may be observed macroscopically (and olfactorily) during the following week. Each day, at the beginning of the class period, place the bowls where each student can observe all bowls—at least in a cursory way. It is too time-consuming to have all students make detailed notes on all bowls; each should concentrate on the bowl the individual student has helped to set up.

One week after they have been set up, the materials in the bowls should be ripe for microscopic observation. Students having like bowl numbers should work together as a group. Provide each of these 8 groups with whatever optical equipment they seem to require. For example, observing organisms in bowl 3 requires monocular microscopes but not hand lenses or stereomicroscopes.

Discussion

The first step is exchanging reports of observations among students, either orally or by means of duplicated sheets.

2. Usually molds are found in the largest number of dishes. Partly this is because bacteria, which are probably more widespread, are difficult to find without special techniques. And partly it is because molds grow better at the temperatures that prevail in most laboratories.

3. A definite diminution of material should be noticeable, especially in bowls 1, 5, and 6. This may be due to desiccation, but for the most part the food is being consumed by the organisms.

These questions present opportunities for discussion to proceed in many directions. It is particularly desirable to stress the fact that, in this "garden," foods—not merely inorganic nutrients—are provided for the microorganisms, since the great majority are consumers. Because most of the organisms occur in situations where decomposition is proceeding, it is obvious that most are decomposers, though there is no clear-cut way to distingush them from other consumers. Also, the possible presence of predators and parasites cannot be excluded. Actively exploit discussion of ecological relationships.

Investigation TRB.7 MICROBIAL TECHNIQUES: MICROSCOPIC STUDY

Materials (per team)

mixed culture of bacteria
crystal violet solution
glycerin
monocular microscope
bunsen burner or alcohol lamp
microscope slide
coverslip
inoculating loop
beaker
dropping pipet
glass-marking pencil
paper towels

Procedure

Part A—Staining Bacteria

1. Gently heat a clean slide by passing it just above a burner flame 3 times. Sterilize an inoculating loop by passing it through the burner flame. When the slide and the loop are cool, place a loopful of the mixed culture of bacteria on the slide. Use the loop to spread the liquid over an area the size of a nickel. Flame the loop again. With a glass-marking pencil, mark the slide, on the side having the bacteria on it. Let the slide dry in the air; an almost invisible film of bacteria will remain.
2. *Quickly* pass the slide *through* the flame 3 or 4 times, film side up. The slide should feel just uncomfortably hot if touched to the back of your hand. Let it cool to room temperature.
3. Fill a beaker with tap water to about 3 cm from the top. Place the slide across the top of the beaker with the film surface up. Cover the film with 3 or 4 drops of crystal violet solution. Allow the stain to remain on the film for 15 seconds. Rinse off the stain by pulling the slide gently to one side until one end drops slowly into the water (figure TRB.7–1).
4. Remove the slide. Empty the beaker and refill it with clean water. Gently dip the slide into the water several times. Drain the water from the slide by holding it vertically and pressing a lower corner against a paper towel. Remove the remaining water by blotting gently with a folded paper towel. Close the towel over the slide as you would close a book. Do not wipe the slide. When the film is dry, add a drop of glycerin, then a coverslip.

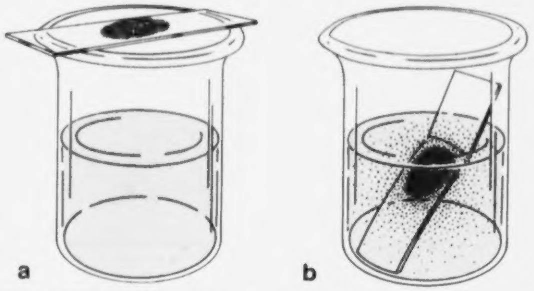


Figure TRB.7–1 Staining procedure.

Part B—Examining Stained Bacteria

1. Use the low-power objective of a microscope to focus on the stained bacteria on the slide. Many species of bacteria can barely be seen with low power. They may appear only as tiny colored specks. Move the slide around until a group of such specks is located near the center of the field of view. Swing the high-power objective into place, and, if necessary, refocus with the fine adjustment.
2. In your data book draw a circle about 6 cm in diameter to represent the field of the microscope. In the circle carefully draw the organisms you can observe. Try to show accurately their shapes, the ways they are grouped, and their sizes in relation to the diameter of the field of view.
3. Estimate the sizes (diameter of round organisms, length and width of others) of the smallest and largest bacteria on your slide. Record the dimensions in micrometers. Do all the bacteria appear to have reacted to the stain in the same way? If not, how do they differ?

For Further Investigation

You can make observations at a magnification close to 1000× if microscopes with oil-immersion objectives are available. After the object is in focus with the high-power objective, swing the objective away. Put one drop of immersion oil directly on the stained bacterial film. Slowly swing the oil-immersion objective into place, to dip into the drop of oil *without* touching the slide.

Investigation TRB.7 MICROBIAL TECHNIQUES: MICROSCOPIC STUDY

Materials

The actual time for this investigation need not exceed 30 minutes, exclusive of time for studying directions and for cleaning up.

A peppercorn infusion made by adding 1 g peppercorns to 200 ml tap water will provide a good variety of bacteria in 2 or 3 days. Materials obtained from investigation TRB.6 also can be used.

Crystal violet solution:
Dissolve 2 g crystal violet (gentian violet) in 20 ml ethyl alcohol (95%). Add 180 ml distilled water. Filter just before using.

Procedure

Flaming the loop before and after use should be practiced for the sake of microbiological principle.

Mounting the stained film by adding a few drops of glycerin and a coverslip makes the color of the stain appear more brilliant and permits the "high dry" objective to be used at maximum resolution—an important factor in the study of such small organisms.

Some teachers provide blank slide labels. A student may mark such a label (with the name of the organism, the date, and the student's initials), affix the label, and keep the finished slide as a souvenir. (If glycerin has been used, it should be rinsed off in several changes of water). You can make a permanent mount by placing a few drops of Canada balsam or Permount on the dry film and adding a coverslip.

The oil-immersion lens is not essential; after all, Leeuwenhoek observed bacteria in a peppercorn infusion with a lens magnifying 270×. An oil-immersion microscope adds more interest to the observation of stained bacteria. To point up the extent of magnification possible, make a simple comparison: To the center of the chalkboard fasten a 1-mm square of white paper; around this, mark off a 1-m square. The bacteria, when viewed under the oil-immersion microscope, are magnified to a similar degree. From this illustration students can get an indication of the minute size of bacteria. Caution students to use only the fine adjustment, and turn it back and forth only a small fraction of a full turn at a time.

Investigation TRB.8 MICROBIAL TECHNIQUES: POPULATIONS

Introduction

If you have a mixed population of horses, cattle and sheep in a pasture, it is easy to separate the 3 kinds of animals and determine the number of each. If you have a mixed population of microorganisms, how can you separate the kinds? How can you obtain a pure culture—a population of one species growing in a medium? How can you count the individuals?

There is a further difficulty. Occasionally horses and cattle may be dangerous, but at least you can see them coming. How can you protect yourself from dangerous kinds of microorganisms? You will follow sterile procedures that have been developed. **CAUTION:** *During the work, keep your hands away from your eyes, ears, nose and mouth. Wash and disinfect your hands afterwards.*

Materials (per team)

culture tube (with plug) containing mixed culture of bacteria
4 culture tubes (plugged), containing 15 ml sterile nutrient agar
2 beakers, 1000 ml
4 sterile petri dishes
inoculating loop or micropipet
test-tube rack
ring stand
bunsen burner or alcohol lamp
thermometer (−10 to +110° C)
glass-marking pencil
disinfectant soap or solution for hands

Procedure

The following directions will be supplemented with demonstrations by your teacher.

Part A—Preparing the Cultures

1. Stand 4 tubes of nutrient agar in a 1000 ml beaker. Add water to a level above that of the agar in the test tubes.
2. Place the beaker on a ring stand and heat. **CAUTION:** *Bunsen burners and alcohol lamps should never be used in the same classroom. Alcohol is highly flammable and should never be allowed to come in contact with an open flame. Use safety goggles when heating all substances.* When the agar has melted, transfer the tubes to a 2nd 1000 ml beaker containing water at 44° C. Check the temperature of this water bath occasionally. When necessary, heat gently to maintain approximately 44° C.
3. Wash the top of the laboratory table with a soapy paper towel. Place 4 sterile petri dishes on the table. Use a glass-marking pencil to number the dishes 1 through 4. Write on the bottom of each dish, near the edge. Include a symbol to designate your team.
4. Remove the plugs from 1 of your tubes of melted agar. Immediately pour it into dish 3. Pour the agar from a 2nd tube into dish 4. Do not allow the tube lip to touch the dish (figure TRB.8–2). Allow the medium to solidify.
5. Sterilize an inoculating loop or micropipet in the flame of a bunsen burner or alcohol lamp. *(See caution in step 2.)*
6. Remove the plug from the tube of mixed culture of bacteria and from 1 of your 2 remaining tubes of melted agar. With the sterilized loop, transfer a loopful of the culture to the tube of sterile medium.
7. Replug both tubes immediately and reflame the loop. Mix the bacteria and agar thoroughly by rolling the tube between your palms for about 15 seconds. Keep the plugged end up so that the cotton remains dry. Using the pencil, label this tube with a 1.
8. Again, flame the loop. Transfer a loopful of the mixture in tube 1 to the remaining tube of melted medium. Replug the tubes and reflame the loop. Mix in the same way you mixed tube 1. Label this 2nd tube with a 2.
9. Return tubes 1 and 2 to the 44° C water bath for 1 minute to make sure all the agar is melted.

41

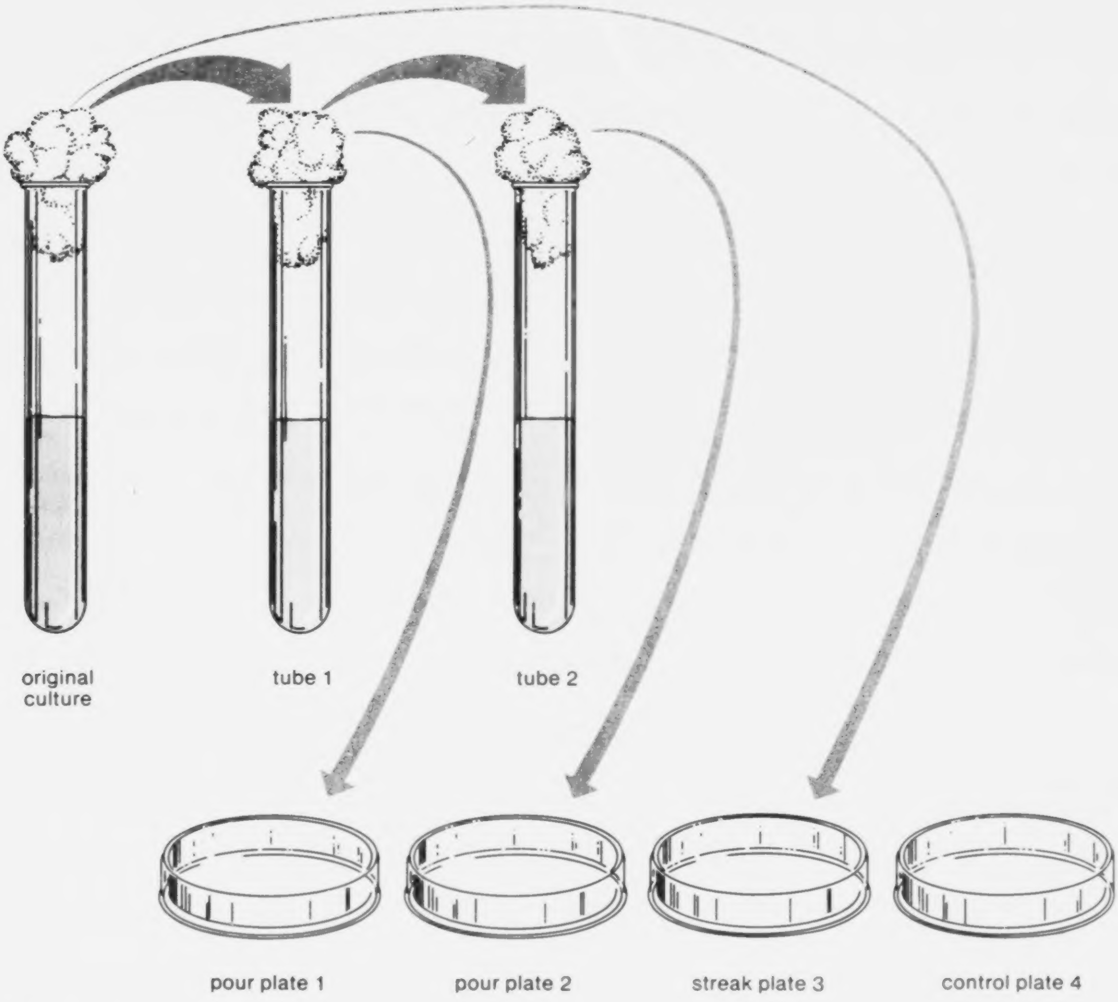


Figure TRB.8-1 Plan for setting up investigation TRB.8.

10. Remove tube 1 from the water bath and dry it with a paper towel. Remove its plug and flame the mouth of the tube. (**CAUTION:** ***Be sure to keep the cotton plug a safe distance from the flame.***) Pour the contents of tube 1 into dish 1. Immediately cover the dish. (The dish is called a plate once it has had the microorganisms added.) Swirl the plate very gently, keeping it on the tabletop. This should distribute the medium evenly over the bottom of the plate. Repeat for plate (dish) 2.
11. As soon as the agar is solid in dish 3 (from step 4), flame the loop. Take a loopful of the original mixed culture and streak the surface of the agar, as shown in figure TRB.8–3a, using one of the patterns shown in figure TRB.8–3b. Flame the loop. Record the pattern used.

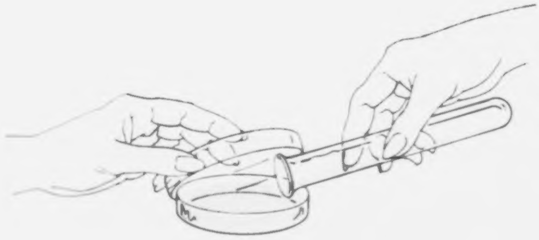
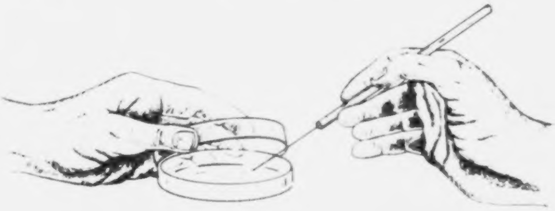


Figure TRB.8-2 Pouring a culture plate.



TRB.8-3a Streaking a culture plate.

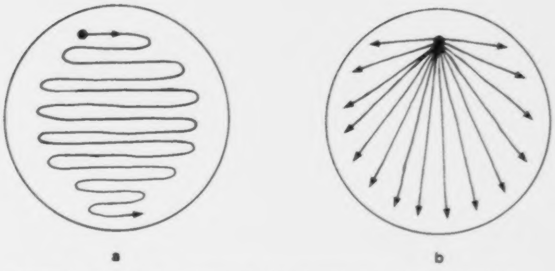


Figure TRB.8–3b Patterns for streaking culture plates.

12. Dish 4 receives no treatment.
13. As soon as the agar is solid, set all the plates upside down in a place designated by your teacher. Observe daily until many bacterial colonies are clearly visible in at least one of the plates.

Part B—Counting the Colonies

1. Ignoring differences in appearance, count the separate colonies of bacteria that have developed in each of the poured plates (1 and 2) and record the counts.
2. In some cases the colonies may be very crowded. You can estimate the number by using the following sampling technique. First, using black ink, draw a 1 cm square on each side of a piece of white paper. Second, position plate 1 on the paper so you can see the colonies of bacteria against the background of the square. Count the number of colonies in the square. Move the square to another position under the plate. Count the colonies again. Repeat until you have 5 counts from different parts of the plate. Third, add all the counts and divide the total by 5. This will give you an average count per cm^2 of the areas sampled.
3. Estimate the number of colonies on the whole plate. To do this, multiply the number or, if necessary, the average number, of colonies per cm^2 by the surface area of the entire plate. (This is 78.5 cm^2 for petri dishes with a 10 cm diameter.) How many colonies do you estimate the plate contains?
4. Repeat calculations for plate 2. How many colonies do you estimate plate 2 contains?
5. Examine plate 4 (control). If there are colonies present in this plate, count them. What correction in your original counts should be made if colonies are present in the control plate? Make such a correction, if necessary.

Discussion

When you have completed counts of plates 1 and 2, you are ready to estimate the population density of organisms (number per cm^3) in the original mixed culture of bacteria. You will need the following information:

The volume of liquid held in your inoculating loop was about 1/200 cm^3. Therefore, the loopful of material introduced into plate 1 contained about 1/200 of the number of bacteria in each cm^3 of the original culture.

Assume that each organism in plate 1 produced a visible colony. Then, the number of colonies in plate 1 multiplied by 200 gives the number of bacteria per cm^3 in the original culture.

1. What do you estimate was the density of bacteria in the original culture?

   Now estimate the density of bacteria (per cm^3) in the original culture using the data from plate 2. To do this, multiply the estimated number of colonies in plate 2 by 600,00. (Can you determine why the factor is 600,000?)
2. What is the density (per cm^3) of the bacteria in the original culture based on these data?

   You now have 2 separate estimates of the number of organisms present per cm^3 (density) in the original culture.
3. How closely do these compare with each other? Also compare with other teams.
4. If there is any difference, how do you account for it?
5. Which calculation do you think is more accurate? Why?

   Next, examine plate 3—the streak plate. Compare the pattern of colonies with the pattern of streaking that you recorded.
6. Are the patterns different or similar?
7. How many kinds of colonies have developed? In what ways do they differ?
8. How many kinds of bacteria were in the original culture?
9. What seems to be the principal way in which the colonies of these bacteria differ macroscopically?

   Suppose you were to lift a part of one colony with a sterile inoculating loop and streak it on a plate of sterile medium.
10. How many kinds of colonies would you expect to develop?

11. What would you call such a culture?
12. Which steps in the procedure are concerned only with determining the population density of microorganisms?
13. Which steps are concerned only with obtaining a pure culture?
14. Review the safety guidelines in appendix 1 and formulate a set of rules for working safely with microorganisms.
15. Suggest a method of safely disposing of the cultures after you have finished studying them.

Investigation TRB.8 MICROBIAL TECHNIQUES: POPULATIONS

This investigation pays dividends more in appreciation than in specific knowledge. It also provides a good gauge of how well your students have learned to understand and follow directions, to work together in teams, and to relate procedures to outcome.

Make careful check of materials and, keeping in mind the quantities of glassware available, decide on team size. For 5 classes of 30 students each, using teams of 3 will require 200 test tubes and 200 petri dishes. Even in teams of 4, each student will be able to participate actively. To cut down the quantity of glassware needed, stagger the scheduling of the investigation for different classes.

Materials

If you do not wish to purchase standard nutrient agar from a biological supply house, the medium can be prepared by a special team of students. For 40 culture tubes you will need:

10 g granulated agar
3.3 g peptone
2 g beef extract
666 ml distilled water
40 test tubes, 18 mm × 150 mm
graduated cylinder, 10 or 25 ml
graduated cylinder, 250 ml
beaker, 1000 ml
stirring rod
wire test-tube basket or other suitable container
funnel, 10, 12, or 14 cm
ring stand and ring
rubber tubing to fit funnel tube
pinch, or spring-compressor, clamp
autoclave or pressure cooker
heat source
balance
nonabsorbent cotton
glass-marking pencil

Using the small graduated cylinder, place 15 ml water in a test tube and mark the level with a glass-marking pencil. Pour out the water. Use this tube as a ruler, and mark the 15 ml level on enough tubes to provide 4 for each team.

Heat the water to just below boiling. (If your tap water is relatively free of dissolved minerals, you may use it in place of distilled water.) Dissolve the agar; then add peptone and beef extract. Heat, stirring continuously, until the mixture comes to a boil. Attach a short piece of rubber tubing to the stem of a large funnel and place a pinch clamp on the tubing. Support the funnel on a ring stand at a convenient height. While the liquid is still warm (above 55° C), pour it—a little at a time—into the funnel. A little practice in using the pinch clamp facilitates filling the marked tubes. Plug them with cotton. Place the tubes in wire baskets, and sterilize in an autoclave at 15 psi pressure for 15 minutes.

With a little trial and error, you can make inoculating loops that hold close to 5 mm^3 (1/200 ml). If you have them, micropipettes may be used in place of loops.

The K-12 strain of *Escherichia coli* has whitish colonies; *Micrococcus luteus* has yellow colonies. For greater contrast with the *M. luteus*, you may decide to use the red bacterium *Serratia marcescens*. It has never been known to infect healthy individuals in laboratories where sterile procedures were being applied.

For counting colonies, transparent, printed grids are useful. They are available from biological supply houses. Use a bacteriological incubator if you wish to maintain a high and more even temperature than that of your room.

Procedure

Although the bacteria being cultured are ordinarily harmless, observe sterile procedure throughout the work. It is possible for pathogenic organisms to get into the medium and multiply. Moreover, a demonstration of handling microorganisms safely is one of the purposes of the investigation. At the end of the work, *all tubes and petri dishes must be sterilized* in an autoclave or pressure cooker *before* the medium is cleaned out of the glassware.

Discussion

1, 2. The density calculation depends on the students' data. Before tube 1 was poured, a loopful of its contents was transferred to tube 2. The volume of medium in tube 1 was 15 cm^3 and that of the loopful of material was 1/200 cm^3. The loopful, therefore, contained 1/15 × 1/200 (= 1/3000) of the number of organisms in tube 1. But tube 1 contained only 1/200 of the organisms in the original culture; thus, tube 2 must contain 1/200 × 1/3000 (= 1/600,000) of the number of organisms per cm^3 in the original culture. Therefore, to obtain the number of organisms per cm^3 in the original culture, students must multiply the number of colonies in Plate 2 by 600,000.

4, 5. In these dilution procedures there are, of course, a number of sources of error, which may be identified by alert students. These can serve as good starting points for discussion. One course, of minor import, is that the individual organisms removed from tube 1 by means of the loop are still absent in the pour plates prepared from tube 1. Another, of far greater significance, is that organisms might not survive the rigors of the handling and dilution procedures and will, therefore, not give rise to visible colonies. Also, incomplete mixing of the organisms introduced into the tubes leads to sampling errors. Finally, variations in the dimensions of the loops used by different teams can result in differences in data.

7, 8. This is the same as the number of kinds of colonies—assuming that all kinds produce colonies distinctively different in appearance. The assumption is probably warranted in this case of a deliberately constructed "mixed culture." But generally speaking, "kinds" cannot be equated with "species" because in many bacterial species various kinds of colonies may be produced, depending on environmental circumstances and stains within species.

10. If you lift only from a single colony, then all organisms on the loop should be of a single kind, since all in the colony descended from a single individual.

11. This would be a pure culture.

12, 13. In general, the tubes and pour plates are concerned with the determination of population density and the streak plates with obtaining a pure culture.

14, 15. See the paragraph on "Procedure." Students should also wash their hands with soap and water, then rinse their hands in a disinfectant, after working with bacteria. They should keep their hands away from their mouth, nose, and eyes during the investigation.

Evaluation of procedures should be a habit by this time. Have the class consider the following:

(a) What were some of the possible sources of error in estimating the number of bacteria in a culture by the methods used in this investigation?

(b) How might the kind of medium and the temperature of incubation influence the number of colonies?

(c) How could you use the pour-plate method to compare rates of growth for 2 different kinds of bacteria in a mixed culture?

Investigation TRB.9 SPONTANEOUS GENERATION

Introduction

Do microbes arise without parents from the nonliving materials in meat broths—abiogenesis? Or do they come from living ancestors (biogenesis) that have somehow gotten into the broths? At the time of the American Revolution, an Italian, Lazzaro Spallanzani, conducted experiments in an attempt to answer the question. Later, in the middle of the 19th century, Pasteur carried out more carefully designed experiments.

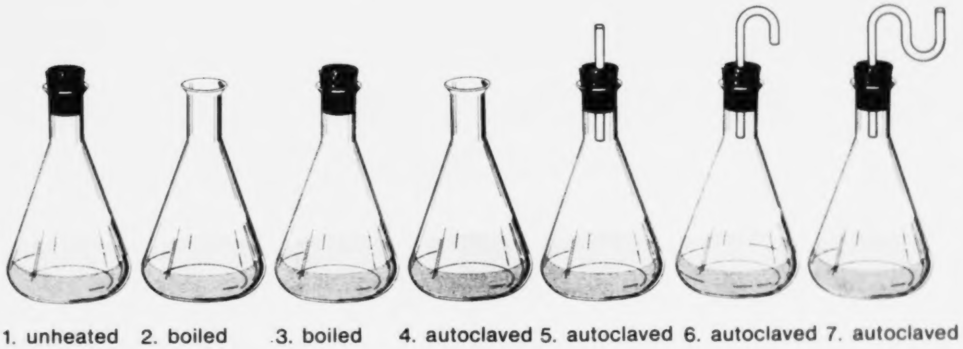
In this investigation you will perform experiments similar to those of Spallanzani and Pasteur. You will use some techniques developed since their day, but the principles involved in your procedure will be the same.

Materials (per team or class)

bouillon cube or 8 g peptone
2 pieces glass tubing 30 cm long
1 piece glass tubing 8 cm long
7 erlenmeyer flasks, 250 ml
bunsen burner with wing tip
3 1-hole stoppers to fit flasks
2 solid stoppers to fit flasks
beaker, 1000 ml
beaker for melting paraffin
stirring rod
funnel
ring stand to fit funnel
graduated cylinder
forceps and wad of cotton
paraffin
autoclave or pressure cooker
heat source
triangular file
filter paper

Procedure

1. Using a wing-tip burner, bend 1 of the 30-cm lengths of glass tubing into a J shape. Bend the other into an S shape (figure TRB.9–1). Trim the tubes to look like those in the illustration. Insert them into 1-hole stoppers. Insert the 8-cm (straight) piece of glass tubing into the 3rd 1-hole stopper. CAUTION: *While inserting the glass tubing through the rubber stoppers, wrap a piece of paper towel around the glass tube to protect your hands.*
2. Dissolve 1 bouillon cube in 500 ml warm water. When cool, filter. The broth must be clear.
3. Pour 70 ml of the broth into each of 7 flasks.
4. Using a lead pencil, number each flask on the small white area on its side. Treat them as follows:
   (a) Flask 1—Plug with a solid stopper. Do not heat.
   (b) Flask 2—Add 10 ml water to the broth. Boil gently for 15 minutes. About 10 ml of water will boil off, making the level approximately the same as in the other flasks. Leave open.
   (c) Flask 3—Add 10 ml water to the broth. Boil gently for 15 minutes, with the solid stopper resting at an angle in the mouth of the flask. Plug immediately with the stopper. To seal, melt paraffin in a beaker; apply it with a wad of cotton held in forceps.
   (d) Flask 4—Heat in an autoclave or a pressure cooker for 15 minutes at 15 psi pressure. Leave open.
   (e) Flask 5—Plug with the stopper through which the straight glass tube was inserted. Heat as for flask 4. Then seal with paraffin around the neck of the flask and around the tube where it comes through the stopper.
   (f) Flask 6—Plug with the stopper through which the J-shaped glass tube was inserted. Heat as for flask 4. Seal as for flask 5.
   (g) Flask 7—Plug with the stopper through which the S-shaped glass tube was inserted. Heat as for flask 4. Seal as for flask 5.
5. Record the date on which the experiment is set up. Place all flasks on a laboratory table but not in direct sunlight or over a radiator.
6. Look for changes in the flasks each day for 1 week, then each week for 5 weeks. Record any changes in the clearness of the broth, noting the number of the flask and the date. Record other observed changes in the broth such as appearance of scum, mold colonies, and so on. At the end of the experiment, open the flasks and note the odor of the broth in each.



TRB.9-1 Completed setup.

Discussion

1. Flasks 2 and 3 represent Spallanzani's experiment. What differences did you observe in these flasks during the 5 weeks?
2. How can you explain the differences?
3. In your experiment, flask 3 may or may not have developed cloudiness. Spallanzani's sealed flask developed no cloudiness or putrid odor. Biologists of his day denied that this showed microbes had to get into the broth from the outside. They clung to the theory of spontaneous generation. How do you think they defended their point of view against Spallanzani's evidence?
4. Flasks 4 to 7 represent some of Pasteur's work. In the experimental setup, what is the function of flask 4?
5. How do you explain the result obtained in flask 7?
6. What is the function of flask 1 in this investigation?
7. Compare your observations of flask 1 with those of flasks 2 and 4. Explain any likenesses and differences in these results.
8. In the light of the results of these experiments, discuss the question raised in the introduction to this investigation: "Do microbes arise without parents from the nonliving materials in meat broths? Or, do they come from living ancestors that have somehow gotten into the broth?

Investigation TRB.9 SPONTANEOUS GENERATION

There is no need for more than one setup per class; the thinking is much more important than the manipulations. If you have more than one class, replication by classes may show some variation in results.

Materials

Filtering is unnecessary if you use about 8 g of peptone in place of the bouillon cube.

If the flasks do not have ground-glass areas that can be written on with lead pencil, label the flasks before sterilizing by using cardboard tags tied on with string. Do not use a glass-marking pencil on flasks that are to be heated or autoclaved.

Procedure

A few students working outside of class time may prepare the materials. Preclass preparations can include mixing the medium, bending the tubing, constructing the stopper combinations, and autoclaving flasks 4, 5, 6, and 7. (Stoppers should be loose in necks of the flasks during autoclaving.) Students who have prepared media for other investigations can do the same here with a minimum of supervision. The work with glass tubing is new, however, and you should supervise it closely. Be particularly careful in inserting the glass tubing through the rubber stoppers. To make this operation safer, use a cork borer with an inside diameter just large enough so that the tubing fits into it. Insert the cork borer through the hole in the stopper, slide the tubing through the borer to the desired distance, and then, holding the tubing in place, withdraw the borer.

The preparation team can conclude the work in front of the class by boiling flasks 2 and 3 and sealing the stoppers in flasks 3, 5, 6, and 7 with paraffin. (Be sure the stopper of flask 3 is tilted in the mouth of the flask during boiling.) Flasks that were labeled with tags can now be relabeled with glass-marking pencils or with masking tape and pencil.

When observations are made, flasks may be picked up for examination, but they should not be shaken.

Many students have difficulty working with this many variables. Ask them to compare 2 flasks at a time. When they do this, they can generate hypotheses about what is happening and use observations of the remaining 5 flasks to support or refute their hypotheses.

Discussion

Typical results are as follows:

Flask 1 becomes turbid within a day or two. In this and the other flasks that become turbid, patches of mold often develop on the surface of the medium.

Flask 2 usually becomes turbid a day or two later than flask 1. Before the experiment ends, its contents usually have evaporated.

Flask 3 may take a very long time to become turbid; indeed this may never happen. Nevertheless, resistant spores of some bacteria may survive and eventually produce turbidity.

Flask 4 usually becomes turbid at about the same time as flask 2. Its contents usually disappear by evaporation.

Flask 5, with its small opening, may not become turbid for many days or even weeks, if there are few air currents. If you keep it long enough, turbidity will appear.

Flask 6 often remains clear long after the experiment has been concluded.

Flask 7 should remain clear as long as it is undisturbed. Some flasks of this kind have been dated and kept for years as exhibits. The design of the S-shaped tube is comparable to that of Pasteur's "swan-neck" flask.

Your students may ask for evidence that the turbidity is caused by bacteria. Check flasks 2 and 4 using the methods of investigation TRB.7. Usually students will find many bacilli and cocci on their slides, and these can be compared with prepared slides of known bacteria.

1,2. If flask 3 becomes cloudy, it usually does so much later than flask 2. Boiling kills most if not all of the organisms originally present in the broth. Although boiling kills organisms in flask 2, new organisms can enter from the air.

3. Believers in abiogenesis argued that microbes did not develop in Spallanzani's sealed flask because heating had destroyed the "power" of the air in the flask and there was no way for new air to enter. Anaerobic organisms were unknown then. Though Spallanzani failed to make his point theoretically, the practical import of his work followed rather quickly. Some of Napoleon's success has been attributed to the mobility of his troops, which was possible because they carried food preserved by canning.

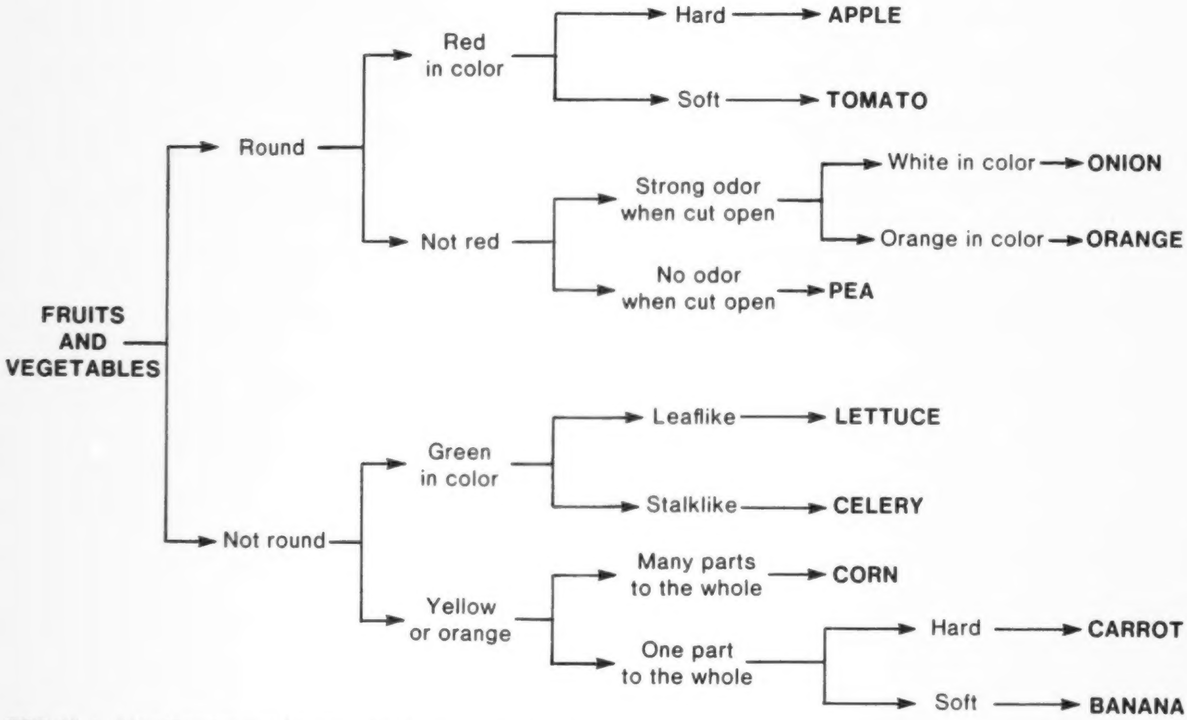
5. The curve in the tube forms a trap. Dust particles bearing spores of microorganisms do not get beyond this point even when air currents outside the flask are rather strong. If autoclaving was done properly and sealing was done promptly, no living organisms will be present in the broth. The tubing prevents new living ones from entering, and no turbidity will develop. The single curve in flask 6 has no such trap, but since it is a rather effective barrier, growth of microorganisms may not appear during the time of the experiment. Pasteur went one step further, he tilted a swan-neck flask until its contents flowed into the crook of the tube; soon thereafter a growth of microorganisms appeared in the flask.

6. Flask 1 is an overall control against the variable of heating.

7. Growth of microorganisms may appear almost simultaneously in flasks 1, 2, and 4, but it may occur slightly sooner in flask 1. Presumably, this results from an abundant supply of microorganisms in the broth at the beginning, while growth in flasks 2 and 4 depends on microorganisms entering the broth after heating.

8. If results are not somewhat similar to those described above, the whole experiment may be inconclusive. In this case center the discussion on reasons for discrepancies between the class data and results reported by Spallanzani and Pasteur (and many later investigators). If results are similar to those described previously, lead the students to see that the experiment discredits the idea that microorganisms can arise from matter that has no living organisms already in it. The idea in the introduction may be put into a hypothesis expressed in negative terms such as: "Microorganisms cannot arise unless they have ancestors." You then have the opportunity to discuss the impossibility of proving a negative proposition. The best that can be done is to amass evidence making the proposition increasingly likely. This kind of evidence for biogenesis eventually led to abiogenesis being discredited.

Investigation TRB.10 DIVERSITY AMONG PLANTS: LEAVES


FRUITS AND VEGETABLES
Round
Red in color
Hard
APPLE
Soft
TOMATO
Not red
Strong odor when cut open
White in color
ONION
Orange in color
ORANGE
No odor when cut open
PEA
Not round
Green in color
Leaflike
LETTUCE
Stalklike
CELERY
Yellow or orange
Many parts to the whole
CORN
One part to the whole
Hard
CARROT
Soft
BANANA

TRB.10–1 Identification key for some fruits and vegetables.

Introduction

Suppose a visitor to Earth from another planet were to wander into a fruit market. Because the visitor does not yet know the names of the fruits and vegetables there, you might provide the identification key shown above.

You probably will recognize that the table is a kind of dichotomous key. When such a key is made, a group of objects is divided repeatedly into smaller groups. Each division is based on sharply contrasting characteristics. Wherever possible, the characteristics used at any point in the key lead to a division into 2 subgroups of about the same size. Eventually, the divisions result in each object being separated from all the others.

Materials (per team)

10 leaves (set A): 1 each from 10 plant species, mounted on cards. The cards, numbered 1–10, are labeled with the plant names.

10 leaves (set B): 1 each from the same 10 species as set A, mounted on cards. Each card has the same number as the card holding the corresponding leaf in set A, but no name.

Procedure

1. Construct a dichotomous identification key for the leaves in set A. Begin by spreading all the leaves on the table in front of you. Study each leaf. In what ways does it resemble the others in the set and in what ways does it differ?
2. What kinds of characteristics should you look for? A few suggestions follow:
   (a) Are there 2 distinct regions in the leaf—a stemlike portion (petiole) and a flattened part (blade)?
   (b) Is the blade all in one piece or is it divided into separate leaflets?
   (c) Is the edge of the blade smooth or is it notched?
   (d) Is the blade uniformly green or are other colors present?
   (e) Is the blade heart-shaped, oval, or spear-shaped?

3. Following the same arrangement as that used in the example above, draw a box at the left margin of a left page in your data book. Label it All Leaves in Set. (You probably will need both the left and the right pages for the complete chart.) Now select a characteristic that gives you 2 choices and divides all the plants into 2 groups, such as shape—round or not round.
4. Draw 2 or more boxes to the right of the 1st box. Label them with the characteristics you used to divide set A into 2 groups. Draw lines that will show this division.
5. Study 1 of the 2 groups. Find a pair of contrasting characteristics that divides the group into 2 subgroups of approximately equal size. Using labeled boxes and lines, place these characteristics in the appropriate positions on your chart. Then do the same for the other group.
6. Continue this process until you have completed a key in which there is a single box or line for each of the 10 kinds of leaves. Label each of these boxes or lines with the name of the plant from which the leaf was obtained, but do not include the identifying number.
7. Use your chart to identify each of the leaves included in set B. Because no two leaves are exactly alike, you may need to change some of the characteristics used in your key, so that it will work with both sets of leaves.
8. Exchange with another team the key and set B (but not set A). Using their key, identify the leaves in their set. Write the number of each leaf next to the name of the species indicated. When you have finished, obtain their set A (which includes both names and numbers) and check your identifications. If you have not achieved complete success, repeat the keying-out process. If differences still turn up, discuss them with the other team. (Two sources of error can occur—one is with the key itself, the other is in the use of the key.)

Investigation TRB.10 DIVERSITY AMONG PLANTS: LEAVES

Leaves are used to emphasize plant diversity because they are easy to obtain and preserve. Attention to diversity through work on key construction emphasizes mechanisms of classification, and it produces student facility with keys. Learning to use a key is a truly educational objective, because it tends to free a student from dependence on others for the identification of organisms.

Materials

Divide your class into teams of 3 or 4 students each. Each team should individually work out a dichotomous key. Thus a class of 30 students requires 7 to 10 sets of named leaves (set A) and 7 to 10 sets of leaves without names (set B) to use in checking the keys. Each set contains 10 different leaves. $10 + 10 = 20$; $20 \times 10 = 200$ leaves. That is quite a few leaves. Collect, press, and mount set of leaves well before the time they are needed for this investigation. Collecting 20 leaves of 10 different species presents no problem in summer or early fall. The specimens of each species should be about the same size.

If a standard press is not available, place the leaves in old telephone directories. Every day or two, depending on the thickness of the specimens and the relative humidity, move the leaves to dry pages in the books. Mount the completely dried specimens on cardboard, and label them.

You can make long-lasting sets of mounts by using clear ConTact paper. This may be purchased in grocery or hardware stores. Place a pressed leaf on a white unlined card (4″ × 6″ or 5″ × 7″). For set A, label the card with the name and number of the specimen; for set B, with the number only. Cut the ConTact paper to fit the card with 2 cm extra to fold over each edge. Press the ConTact paper carefully onto the leaf and card, and fold the surplus over the edges.

If you punch a hole in the upper left corner of each mount, you can hold each set together with a loose-leaf mounting ring. These sets of leaves, when used with reasonable care, are quite durable and should last for several years.

It is, of course, not crucial which particular species you include in each set of leaves, but provide a fairly wide range of diversity. Leaves from woody plants are usually firmer than those from herbaceous plants. They probably will dry without wrinkling.

Procedure

Help students to achieve a clear understanding of the dimensions of diversity—both differences among specimens and differences among species. Usually no two student keys are exactly alike, a result of differences among specimens of one species and of differences among the criteria used to construct the keys. The need for careful observation and description is clearly demonstrated when two teams attempt to use and then evaluate each other's keys. Thus, because the points are made in the doing, a minimum of discussion is required at the conclusion of the work.

Investigation TRB.11 A HEART AT WORK

Introduction

Crustaceans of the genus *Daphnia* are abundant in small bodies of fresh water. Individuals are just large enough to be seen with the naked eye. When magnified even 20 times, many of the internal organs—including the heart—can be seen through the body wall. Before you begin this investigation, become familiar with the appearance of the animals. Look carefully for the beating heart. Do not confuse its motion with that of the legs, which also move rhythmically.

Read through the procedure. State a hypothesis that is appropriate to it.

Materials (per team)

6 to 8 *Daphnia*, in a small beaker of aquarium water
thermometer (−10° to +110° C)
dropping pipet
microscope slide with depression
stereomicroscope
watch with second hand
beaker large enough to hold *Daphnia* beaker
crushed ice
hot water
graph paper, 1 sheet per student
paper towels

Procedure

1. Check the temperature of the water in which the *Daphnia* are living. It should be at room temperature before you begin.
2. With a dropping pipet, transfer 1 *Daphnia* to the depression in the slide.
3. Soak up excess water with a piece of paper towel. By limiting the amount of water, you increase the likelihood that the animal will lie on its side, the position in which heart action can be seen best.
4. Team members should take turns at keeping time with the watch and observing the specimen's heartbeats through the stereomicroscope. It may be difficult to count as rapidly as the heart beats. If so, try tapping a pencil on a piece of paper at the speed of the heartbeat. Then count the pencil dots.
5. When the observer is ready, the timer says "Go." At the end of 15 seconds, the timer says "Stop." Multiply the count by 4 to obtain the number of heartbeats per minute.
6. Make at least 3 timed counts. Return the *Daphnia* to the beaker.

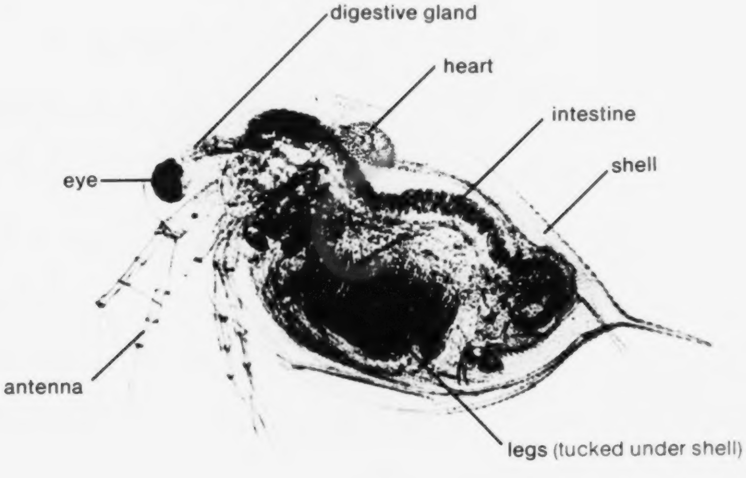


Figure TRB.11-1 *Daphnia*, ×72. Thorne Films, Inc.

7. Place the beaker of *Daphnia* in a larger beaker of water and crushed ice. Stir the water in the *Daphnia* beaker gently with the thermometer. When the water reaches the temperature assigned to your team, quickly transfer a *Daphnia* to a slide. Make at least 3 counts as quickly as possible.
8. As soon as the *Daphnia* is removed from the beaker, members of the team who are not timing or counting should remove the *Daphnia* beaker from the large beaker. Pour out the ice water from the larger beaker and put in hot water (50°–70° C). CAUTION: *Allow the beaker to warm slightly before pouring hot water into it.*
9. Place the *Daphnia* beaker in the larger beaker again. Stir the water in the *Daphnia* beaker gently with the thermometer. By the time the water temperature rises to the 2nd point assigned to your team, counting at the lower temperature should be finished. Quickly transfer a *Daphnia* to the slide. Make at least 3 counts as quickly as possible.

Discussion

1. Consider the heartbeat data obtained from *Daphnia* at room temperature. Why were serveral counts made by each team?
2. What factors might account for the variability in these data?
3. Assemble on the chalkboard the room temperature data from all teams. Calculate the average heart rate at different temperatures. If two or more teams obtained data at the same temperature, calculate the average for that temperature. Graph the data, placing heart rate on the vertical axis and temperature on the horizonal axis.
4. On the basis of your graph, make a general statement about the effects of variation in environmental temperature on the heart rate in *Daphnia*.
5. Does your graph support your hypothesis? Explain.
6. Would you expect similar effects of temperature on the heart rate of a frog? Of a dog? Explain.

For Further Investigation

1. Young pond snails have thin shells through which the heart can be seen, just as in *Daphnia*. Make a study of snail heart rate for comparison with that of *Daphnia*. Try to account for any differences you observe.
2. The easily observed heart of *Daphnia* can lead to some understanding of the way in which drugs affect heart rate. Investigate the effects of alcohol (about 5%) and of stimulant (such as dexedrine sulfate) on *Daphnia* heart rate. Caffeine and epinephrine may also be used.

TEACHER'S ANNOTATIONS

Investigation TRB.11 A HEART AT WORK

Materials

Daphnia may be collected from ponds and lakes during most of the year. They can be ordered from biological supply houses and may be obtained at aquarium supply stores or fish hatcheries. *Daphnia magna* is the largest and, therefore, the species of choice. *D. pulex* and *D. longispina*, though smaller, are also satisfactory. You can maintain a *Daphnia* culture for 1 or 2 weeks in pond water at 22 to 26° C. Keep the culture out of direct sunlight.

A 50-ml beaker is a good container for the *Daphnia*. It must be made of heat-resistant glass, because it will be transferred from ice water to hot water. A 250-ml beaker provides a good water jacket.

If depression slides are not available, make a ring of wax dripped from a burning candle onto a clean slide. Place the drop of water containing the *Daphnia* inside the ring.

If stereomicroscopes are not available, the low power of a monocular scope may be used, but there may be some difficulty keeping the specimen within the field of view.

Procedure

Because the counts must be made quickly, students should become familiar with *Daphnia* in advance. Assign temperatures to teams and have teams decide how they will perform each task of the investigation.

Assuming that room temperature is about 20° C, suggested temperatures are: 15, 10, and 5° C (ice water); and 25, 30, and 35° C (hot water).

It is not necessary to have a separate hot-water supply for each team. Maintain one large container at about 90° C. One laboratory assistant can be responsible for safe distribution of the hot water.

Discussion

The 1st point of this work is the variability of physiological data. Students are often unduly impressed by various "normal" values for physiological measurements, such as body temperature and blood pressure. Compare the heart rate of *Daphnia* at room temperature with that of humans by having students count their own pulses. Assemble these data on the chalkboard. This also will emphasize the variability of data and lead to a better understanding of the many "normal" values found in textbooks on human physiology.

The 2nd point to be stressed—if the data allow you to do so—is the effect of temperature on the physiology of a poikilothermic animal. The normal heart rate of *Daphnia* is usually given as 300–500 per minute. The rate declines with lowered temperatures and rises with raised temperatures, but at about 40° C a decline occurs, and the heart rate usually ceases at about 45° C.

1. By now, this question should be routine.

2. Inaccuracy of counting, temperature variation during the period of positioning the specimen, and variation in age and physical condition of specimens are all likely possibilities.

5. The class average is most likely to be nearer the "true" rate—the rate likely to be obtained from a second series of comparable data—because errors of difference noted in item 2 are compensated as data are averaged. In statistical terms, the more data, the greater the range (item 4) but the less the standard deviation.

6. Homeothermic vertebrates such as dogs keep a steady heart rate despite wide changes in environmental temperatures, because the regulation of heartbeat occurs in the internal environment. Poikilothermic vertebrates such as frogs are similar to *Daphnia*. Their internal processes, including heartbeat, are not well insulated against fluctuations in envrionmental conditions such as temperature.

For Further Investigation

1. In addition to snails, you can use mosquito larvae and *Tubifex* worms for comparisons.

2. Besides the suggested drugs, other substances that might be tried are aspirin, tea, phenobarbital, carbonated beverages, coffee, and tobacco.

Investigation TRB.12 OBSERVING STRUCTURAL CHARACTERISTICS

Introduction

This investigation will provide you with an opportunity to sharpen your skills of observation.

Materials (per class)

animal specimens
hand lenses or stereomicroscopes

Procedure

Part A—Observing Animal Specimens

1. Some animal species are displayed at several numbered stations in your classroom. You may find both living and preserved specimens at some stations. The preserved specimens may be partially dissected so you can make further observations.
2. Divide your class into as many groups as there are displays. Each group will begin making observations at a different display.
3. You will spend a definite amount of time at each station. At the end of each time period, move to the station with the next higher number, until you reach your starting point.
4. Begin by deciding whether each animal you are studying is a vertebrate or an invertebrate. If it is a vertebrate, record its common name on table TRB.12–1 in 1 of the spaces under the heading Name of Animal. If it is an invertebrate, follow the same procedure but use Table TRB.12–2.
5. Across the top of each table is a list of characteristics to help you make observations. Each section includes 2 or more characteristics. After studying the specimens, place a check under each characteristic you observe.

Table TRB.12–1 Structural characteristics

	Skin Structures				Appendages				Skeleton		Teeth		Jaws		
Name of Animal	**Hair**	**Feathers**	**Scales**	**None of these**	**Wings**	**Legs**	**Fins**	**None of these**	**Bony**	**Cartilage**	**Present**	**Absent**	**Present**	**Absent**	**Class**

Suppose that the 1st specimen you study is a cat. A cat has a backbone, so you would use Table TRB.12–1. Now look at the 4 choices indicated in the section Skin Structures. Only 1 of the choices applies to the cat: Hair. Therefore, you put a check in the box that is to the right of Cat and under Hair. Next look at the choices in Appendages. Again there is only 1 choice that applies to the cat, so you check the box under Legs. Proceed across the table in this manner. When you cannot make a decision on any point, leave the space blank.

Part B—Using a Key

Organisms are difficult to identify because there are so many of them. One tool biologists use is called a key. There are several different kinds of keys; you will be using a **dichotomous key.** In this kind of key you must choose between 2 characteristics, which leads you to another pair to choose between, and so on until you reach the identity of the organism.

KEY 1

Dichotomous Key to Classes of the Subphylum Vertebrata

1a. Hair present	Class Mammalia
1b. Hair absent	go to 2
2a. Feathers present	Class Aves
2b. Feathers absent	go to 3
3a. Jaws present	go to 4
3b. Jaws absent	Class Agnatha
4a. Paired fins present	go to 5
4b. Paired fins absent	go to 6
5a. Skeleton bony	Class Osteichthyes
5b. Skeleton cartilaginous	Class Chondrichthyes
6a. Skin scales present	Class Reptilia
6b. Skin scales absent	Class Amphibia

1. With the information you have recorded in table TRB.12–1, use Key 1 to determine the class to which each of the animals belongs. Begin at the top of the key with item 1, where you have choices 1a and 1b. If the animal you are considering has hair, your choice is 1a. Following the 1a line to the right side of the key, you find that it belongs to the class Mammalia. If the animal does not have hair, follow the 1b line to the right. Here you find that you are to go to item 2 in the key, where 2 more contrasting characteristics are indicated, 2a and 2b. Again make a choice and, if necessary, continue down the key to the group with which the animal is classified. Write the name of the class in Table TRB.12–1. Repeat the process for each vertebrate animal.
2. Use Key 2 to determine the phylum for each invertebrate in Table TRB.12–2, and record the phyla in the columns at the right of the table.

KEY 2

Dichotomous Key to Selected Invertebrate Phyla

1a. Body symmetry radial	go to 2
1b. Body symmetry not radial	go to 3
2a. Tentacles present, body soft	Phylum Coelenterata
2b. Tentacles absent, body hard and rough	Phylum Echinodermata
3a. Exoskeleton present	go to 4
3b. Exoskeleton absent	go to 5
4a. Jointed legs present	Phylum Arthropoda
4b. Jointed legs absent	Phylum Mollusca
5a. Body segmented	Phylum Annelida
5b. Body not segmented	Phylum Platyhelminthes

3. Finally, use Key 3 to determine the class in which each of your arthropod animals has been placed. Record this information at the bottom of Table TRB.12–2. (Keys can be made to carry identifications all the way down to the species level.)

Table TRB.12–2 Structural characteristics

Name of Animal	Exo-skeleton		Body Symmetry			Jointed Walking Legs				Body Segments		Tentacles			Antennae			Phylum	Class
	Present	Absent	Radial	Bilateral	No Symmetry	3 Pairs	4 Pairs	More than 4 Pairs	Absent	Present	Absent	More than 4	4 or Fewer	Absent	2 or More Pairs	1 Pair	Absent		

KEY 3

Dichotomous Key to Selected Classes of the Phylum Arthropoda

1a. Walking legs, more than 5 pairs .... go to 2
1b. Walking legs, 5 or fewer pairs .... go to 3
2a. Legs, 1 pair for each body segment .... Class Chilopoda
2b. Legs 2 pairs for each body segment .... Class Diplopoda
3a. Antennae present .... go to 4
3b. Antennae absent .... Class Arachnida
4a. Antennae, 1 pair .... Class Insecta
4b. Antennae, more than 1 pair .... Class Crustacea

4. The simplified keys in this investigation will not always indicate a correct classification for every animal. A key gives you a correct identification only if it is used with the group of organisms for which it was constructed. For example, if you attempt to classify a squid or a slug by using key 2, the key will indicate the phylum Platyhelminthes; both are actually mollusks. Unless you use a key to unlock only the doors for which it was designed, you will end up in the wrong house. Check your identifications by using references such as the Peterson Field Guide Series, edited by T. R. Peterson. (Boston: Houghton Mifflin).

Discussion

After you have classified all the animals of your laboratory study, refer again to tables TRB.12–1 and TRB.12–2. Once you know that an animal is a vertebrate, you need only determine a single characteristic—possession of hair—to place it in the class Mammalia.

1. Is there any other *single* characteristic that enables you to place a vertebrate in its class at once? If so, what characteristic is it, and in which class should the vertebrate be placed?
2. Does any single characteristic enable you to place an invertebrate that you have studied in its phylum? If so, what is the characteristic and which phylum does it indicate?
3. Is there any single characteristic that enables you to place an arthropod in its class? If so, what is the characteristic and which class does it indicate?

For Further Investigation

Select 10 students including yourself. Construct a dichotomous key using characteristics that will enable another person to identify each student in the group.

Investigation TRB.12 OBSERVING STRUCTURAL CHARACTERISTICS

Materials

Living animals should, of course, be used as much as possible. It is unlikely that more than 20 specimens can be examined in a single period. If diversity is to be evident despite this limitation, a judicious choice of specimens is important.

Further, since the keys in the second part of the investigation are simple, they do not take into consideration exceptional representatives of the groups. Therefore, in choosing specimens, take care to select those that will "key out."

Suggestions:

For table 1: rat or mouse, dogfish, frog or salamander, bat, canary or parakeet, snake, turtle, goldfish, lizard, lamprey.

For table 2: earthworm, crayfish, jellyfish, hydra, butterfly or moth, starfish, clam or oyster, beetle, spider (but avoid tarantula), grasshopper, planarian, snail (but avoid slugs), clam worm, millipede, centipede, tick.

Procedure

On the day before students do their observing, go over the directions with them. Have students divide themselves into as many groups as there are stations and assign the station with which each group will begin. Agree on a signal for changing from one specimen to the next. During the observation period you merely give the signals for change of station and make sure that the operation proceeds smoothly.

At the beginning, allow at least 3 minutes at each station. This time can be reduced as students become familiar with the tables. Having vertebrate specimens at consecutive stations and invertebrate specimens at consecutive stations usually increases ease with which students work.

Procedure B can be done in small groups or assigned as homework. However, in classes where many students have reading difficulties, you should assist students in working several examples through the keys before allowing them to work independently. It is important to call special attention to step 4 of Procedure B.

Discussion

1. Any vertebrate with feathers can immediately be placed in the class Aves.

2. Any invertebrate that has jointed appendages can immediately be placed in the phylum Arthropoda.

3. Any arthropod without antennae can be placed in the class Arachnida. Any adult arthropod with 3 pairs of legs on the thorax can be placed in the class Insecta.

Investigation TRB.13 PLANARIAN BEHAVIOR

Introduction

Planaria are common, free-living flatworms that live in fresh water. They have a simple nervous system consisting of 2 cerebral ganglia and a "ladder-type" nerve cord. The responses of planaria are often referred to as taxes.

Read through the procedure and write a hypothesis you think it was designed to test.

Materials (per team)

planarian (*Dugesia tigrini*)
dechlorinated water
2 microscope slides
test tube, 13 mm × 100 mm
cork stopper to fit test tube
test-tube rack or small bottle
square of aluminum foil, 12 cm × 12 cm
dropping pipet
dissecting needle
glass-marking pencil
sheet of white paper

Procedure

1. With the dropping pipet, remove 1 planarian from the culture bottle. Quickly and gently release the water containing the animal into the test tube. (The planarian may fasten itself to the dropping pipet. If it does so, squeeze water rapidly but gently in and out of the pipet to prod the animal loose).
2. Add dechlorinated water to the test tube until it is nearly full. Insert the stopper. When the stopper is inserted, it should displace some of the water. This eliminates the possibility of an air bubble in the tube. Draw a line at the midpoint of the test tube. Hold the test tube horizontally until the flatworm has moved near the center of the tube.
3. Place the test tube, cork end up, in the test-tube rack or small bottle. It should be illuminated evenly from all sides. Why is this necessary? Observe the planarian for 10 minutes. Record how much time it spends in each half of the tube.
4. Hold the test tube horizontally until the flatworm has moved near the center of the tube.
5. Place the test tube, cork end down, in the rack or bottle. Again, observe and time the reaction of the planarian. To what environmental factor do you think the animal is responding? Is its response negative or positive?
6. Again, hold the test tube horizontally until the flatworm has moved near the center of the tube. Lay the tube on a sheet of white paper on a flat surface. (If the tube is not level, stack 1 or 2 microscope slides under the low end.)
7. Observe the planarian for 10 minutes. Record how much time it spends in each end of the tube. Be sure the test tube is evenly lighted with diffuse room light along its entire length.
8. Form a cap of the aluminum foil to fit over the rounded end, covering about ½ of the test tube.
9. Wait until the planarian is near the middle of the tube and is headed for the corked end. Then slip the aluminum-foil cap over the rounded end of the tube.
10. For another 10 minutes record the time the planarian spends in each end of the tube. What is the stimulus for this response? Is the response negative or positive?

Discussion

1. Can you use your results of this investigation to describe the behavior of all planaria? Why or why not?
2. Did all of the class's planaria behave similarly?
3. What might be the advantage of these behaviors for the planaria?

Investigation TRB.13 PLANARIAN BEHAVIOR

This simple investigation provides an example of the type of controlled laboratory research that results in increased knowledge of the relationships between physiology and behavior.

If you are not already maintaining cultures of planaria, refer to F. Barbara Orlans, 1977, *Animal Care from Protozoa to Small Mammals* (Menlo Park, Cal.: Addison-Wesley) pp. 50–56.

Procedure

3. Illumination should not be a variable in this part of the investigation.
5. Gravity (geotaxis). Positive.
10. Light (phototaxis). Negative.

Discussion

1. The behavior of a single planarian could vary from the pattern characteristic of the species. Results from several experiments with different planaria under the same controlled conditions should be compared before a generalization is made.

3. Such behavior would keep a planarian among the rocks or plants at the bottom of a pond or stream where it is safer from predators than it would be near the surface of the water.

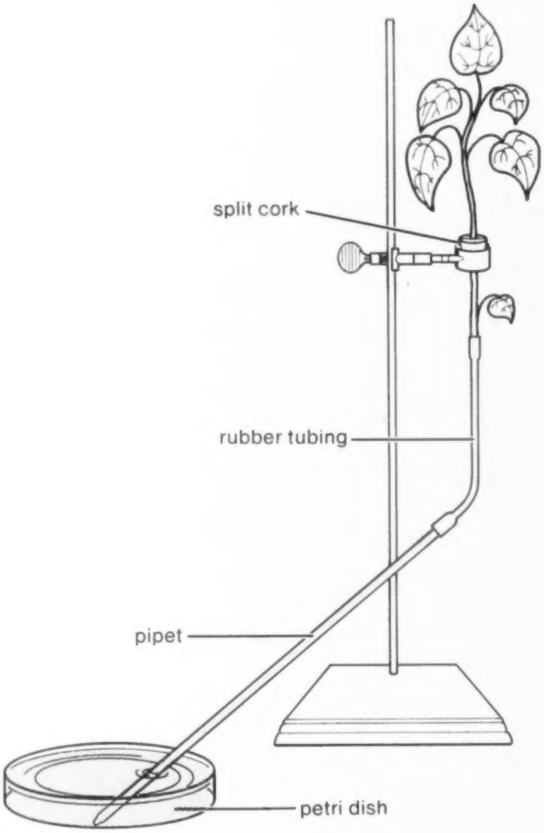
Investigation TRB.14 TRANSPIRATION

Introduction

Transpiration is one of the processes involved in the movement of water from the roots to the top of a plant. What factors affect the rate of transpiration?

Materials (per team)

deep, 30-liter container (for entire class)
leafy potted plant (all teams but one)
large battery jar or bowl
graduated pipet, 1 ml
beaker, 400 ml
solid glass rod (1 team only)
bottom half of petri dish
scalpel
buret clamp
ring stand
1-hole, split cork
rubber tubing, about 20 cm long
watch
water at room temperature
paper towel
plastic bag
string, 15 cm long



TRB.14–1 Completed setup.

Procedure

1. Read the procedure and then state a hypothesis appropriate to the design of the experiment. All teams except a control team will follow steps 2 through 6.
2. Hold a potted plant in a deep, 30-liter container of water (at room temperature) so that the base of the shoot is covered by water to a height of 5 to 10 cm. One team member supports the shoot as another makes a diagonal cut through the base of the shoot. This should be done under the water and close to the soil surface. *Quickly* transfer the cut shoot to a large bowl of water. Hold the shoot so that the cut end is under water and the rest remains dry.
3. Immerse the rubber tubing in the water. Squeeze the tube to force out air so that it is completely filled with water. Keep the tubing under the water and fit an end of it over the cut end of the shoot. The tubing should cover about 1 cm of the shoot.
4. Fill the bottom half of the petri dish with water, almost to its brim. Immerse the tip of a graduated 1 ml pipet in the dish. Suck on it to fill it completely with water. Place a finger over the tip of the pipet and remove it from the petri dish. Insert the other end of the pipet to a distance of 2 cm into the free end of the rubber tubing. Keep both the pipet end and the rubber tubing under water. As this is being done, remove your fingertip and squeeze the rubber tubing to clear any air out of the tip of the pipet. Immediately replace the tip of the pipete in the petri dish of water. Then position the shoot as shown in figure TRB.14–1. Support it by means of a ring stand, clamp, and split cork. The base of the shoot should be about 15 cm above the table surface.

65

5. Now raise the tip of the pipet out of the petri dish and rest it in a horizontal position on top of a small beaker. Place a small piece of paper towel against the pipet lip. Gently apply pressure to the rubber tubing so that a small volume of water is forced out of the pipet and absorbed by the towel. This water will be replaced by air when the pressure is removed. If the setup is operating satisfactorily, the air column should move slowly along the length of the pipet. Wait until the air column reaches a 0.1-ml graduation. Then determine the time it takes to move through the next three 0.1-ml sections of the pipet.
6. As soon as you have recorded the time, place the pipet tip in the petri dish and gently squeeze the rubber tubing until all of the air is forced out. Release the pressure. Now cover the shoot loosely with a plastic bag. Gather the mouth of the bag together and tie it shut around the base of the stem. After 5 minutes, measure the rate of movement of the air column.
7. One team will prepare a control setup substituting a glass rod for the shoot. Except for this difference, the team should carry out procedures identical to those described above.

Discussion

1. (a) Calculate the volume of water per minute removed from the pipet attached to the uncovered shoot.
    (b) Calculate the same for the covered shoot.
    (c) Make the same calculations for the control setup.

   Compare the results from the experimental setup with the results from the control setup.
2. Where do you think water may have been lost from the apparatus in either of the setups?
3. In the case of the experimental setup, does the use of the plastic bag provide any confirmation of this? If so, how? Use the data from the control to correct the data from the experimental setup.
4. Do your data support your original hypothesis? Explain.

For Further Investigation

Design an experiment to determine the rate of water loss from the shoot of a growing potted plant. Use the same species and size as that from which you obtained the shoot used in this investigation. Would you expect the rate of water loss of this plant to be lower, the same as, or greater than the rate of uptake of the cut shoot? Explain.

Investigation TRB.14 TRANSPIRATION

This study tests the validity of a student-formulated hypothesis. It can be done as a demonstration set up by a single team. However, if you can obtain the rather simple apparatus in sufficient quantity, work by a number of teams is better. You then have another opportunity to point out the effect of pooling results from replication. Teams of 4 students should be able to work efficiently.

Materials

If a number of teams are to work, have all materials and equipment conveniently arranged when students enter the classroom. The plants should have sturdy, smooth, cylindrical stems so that the rubber tubing can be fitted over them without damage. Perhaps the most suitable are geraniums. Tomato or sunflower plants can be used if they are mature enough. Be sure the plants have been well watered and are not wilted.

Tubing should be soft gum rubber; its internal diameter should be about 1 mm less than that of the stems and pipets. If the diameter of the stems is significantly greater than that of the pipets, fit a short piece of plastic tubing over the upper end of each pipet so that its diameter closely approximates that of the shoots.

If time and suitable plant materials are available, different teams or groups of teams can use different species of plants. Comparisons then can be made among species. If the number of teams is small, the advantages of replication are lost.

Procedure

Two conditions must be achieved if anomalous results are to be avoided. (a) The seals between the pipet and the rubber tubing and between the stem and the rubber tubing must be perfect. (b) There must be no air present in the entire system. If the lower ends of the shoots are not smooth and cylindrical, you may need to tie string tightly around the stem-tubing junction at one or more levels to ensure seal integrity. Follow the directions for setting up the apparatus meticulously. If the cut ends of the shoots are not continuously covered with water, air will be drawn up into xylem vessels, greatly affecting their water-conducting ability.

If students have not previously used pipets, allow time for practice in filling and reading them.

If transcription rates under classroom conditions are low (high humidity, low light intensity), reduce the interval through which the air column moves along the pipet from 0.3 ml to 0.1 ml. If rates are high, increase the interval to 0.5 ml. The air column must be forced out of the pipet as soon as a measurement has been made and before it reaches the upper end of the pipet. If air is allowed to pass from the pipet into the rubber tubing, it may rise up through the tubing, come into contact with the cut end of the shoot, and block conducting vessels.

Discussion

Have teams record their data on a large chart on the chalkboard. Use the averages from all the experimental teams as a basis for the discussion.

1. The experimental design obviously centers on the presence or absence of the plastic bag. Students might base a hypothesis on the ability of the bag to interfere with air currents. Or they might have observed moisture collect on the inside of a plastic bag containing a plant and may hypothesize on that basis.
2. If all connections are tight, water can be lost only from the free surface of the air column in the pipet (a very small surface and a negligible source of loss) or from the shoot. If all connections are tight, the control setup shows little loss of water. Therefore, greater loss in the experimental setups is linked to the factor by which these setups differ from the control—the shoot. In discussing this question, point out a possibly unwarranted assumption, namely that the volume of water being taken up by the shoot is water replacing that being lost by evaporation (transpiration). Water plays many roles in the economy of a plant. The cells of a wilted shoot would have absorbed some of the water until they were turgid. Students should suggest that small amounts of water are used in photosynthesis and other biochemical processes in plant growth. Actually these amounts of water are so small that they could not be measured with the apparatus employed.
3. The difference between uptake rates of uncovered and covered setups should indicate clearly that it is the shoot and the condition of the atmosphere surrounding it that primarily determine its water loss, the rate at which water is replaced.

Investigation TRB.15 A METHOD FOR STUDYING TERRITORIALITY

Introduction

To determine the nesting territories of breeding birds, investigators first prepare a field map of the area they plan to study. Then they make a series of trips through the area. They indicate on the map the location of each singing male of each species they encounter. They also mark the location of any nests they find. Females and young birds may be indicated also, but a singing male usually is assumed to indicate the presence of a mate and a nest, though this is not always true.

These investigators may use special symbols to indicate such information as two males of the same species heard singing simultaneously, or the locations of fights between males. After they have collected the data, the investigators plot the location of birds noted on each field trip on maps that show individual species. From study of the data on the species maps, they can determine the territories.

You will work with actual, though simplified, field data. These data were collected from a breeding-bird study made on a 30-hectare area in Colorado. Most of the vegetation is composed of shrubs. There are, however, some pine groves, some deciduous trees, and some small grassy areas. You will work with 5 of the 16 species of breeding birds that were found. You will consider data from 6 of the 27 field trips made to the area. These 6 trips were made at the height of the nesting season.

Materials (per person)

5 sheets graph paper
sharp pencil with hard lead (about 4H)

Procedure

1. On each sheet of graph paper outline a plot 40 × 40 squares. Number the horizontal graph lines upward from 0 at the bottom through 40 at the top. Letter the vertical lines from left to right A through Z, then a through o. Write the name of one of the species being studied at the top of each sheet.
2. In the table of data below, the 6 dates of observation are represented by numerals 1 through 6. Beside each date (except for 6) is the location of an individual bird on each of the first 5 dates. Each location has a number and a letter. For example, 37/c is located at the intersection of line 37 with line c. For date 6 use the data in figure TRB.15–1, which is a simplified example of field data. Also listed is the location of each nest that was found. Many nests probably were not found.
3. Plot the location of each bird and nest on the appropriate sheet. Mark the location of a bird by placing the date number (1 through 6) at the appropriate intersection of lines. Mark the location of a nest with a check (✓).

Discussion

1. Compare the 5 territory maps. What generalization can you make about the sizes of breeding territories for different species? Explain.
2. Do territories of different species overlap, or is each portion of the study area used only by one species of bird?
3. Red-tailed hawks are often seen here, but no nest has been found. What may be the relation of the size of a red-tailed hawk's territory to the size of this study area?
4. In the region where this study was made, robins have a tendency to nest in deciduous trees along ravines; solitary vireos in pine groves; and scrub jays and rufous-sided towhees in brushland. Look at the distribution and population density of these 4 species. Which of the habitats mentioned seems to be most widespread in this 30-hectare plot?
5. Flickers nest in holes in trees but feed on the ground, mainly on ants. What might explain the low population density of this species here?
6. What appears to be the approximate carrying capacity of this area for adult rufous-sided towhees during the breeding season?
7. Why might this area not have as great a carrying capacity for towhees in the winter season?

Red-shafted Flicker (males)

Date 1: 37/H; 21/F
Date 2: 39/J
Date 3: 38/K
Date 4: 35/M
Date 5: 34/L
Date 6: See Figure TRB.15–1
Nest: 35/K

Solitary Vireo (singing males)

Date 1: 36/B; 29/V
Date 2: 30/B; 29/U
Date 3: 30/U
Date 4: 37/B; 29/X
Date 5: 32/A; 30/a
Date 6: See Figure TRB.15–1
Nest: 31/a

Robin (singing males)

Date 1: 4/F; 17/S; 33/Q; 29/b; 33/j
Date 2: 9/D; 22/Q; 29/Q; 32/Z; 30/i; 10/o
Date 3: 9/M; 17/U; 32/S; 33/c; 30/k
Date 4: 3/M; 21/N; 33/V; 32/Y; 35/j
Date 5: 2/G; 14/R; 28/R; 27/f; 29/j
Date 6: See Figure TA–6
Nest: 29/S; 32/i

Scrub Jay (males or females)

Date 1: 33/A; 17/J; 1/Z; 23/f; 37/i
Date 2: 29/G; 17/R; 5/Z; 26/g; 39/j
Date 3: 35/M; 18/N; 10/b; 23/l
Date 4: 38/D; 13/S; 4/c; 26/h; 39/l
Date 5: 35/L; 23/R; 6/Z; 27/d; 36/o
Date 6: See Figure TA–6
Nest: 9/c; 25/i; 38/n

Rufous-sided Towhee (singing males)

Date 1: 40/a; 28/F; 37/H; 22/F; 25/I; 28/K; 37/P; 31/S; 25/P; 34/Y; 38/c; 12/Y; 11/G; 39/g; 34/j; 27/l; 31/e; 25/b; 4/I; 2/Q; 9/N; 15/L; 7/g; 11/m; 17/h; 21/W
Date 2: 36/C; 37/G; 22/I; 28/I; 36/S; 30/R; 24/R; 32/X; 36/d; 37/l; 8/c; 26/l; 12/j; 30/m; 30/d; 28/z; 12/e; 4/M; 20/Z; 3/S; 14/X; 11/P; 14/P
Date 3: 35/B; 28/A; 33/J; 25/K; 28/M; 33/R; 29/R; 27/V; 31/W; 35/a; 12/X; 37/h; 31/I; 5/d; 24/j; 29/c; 11/j; 15/f; 27/a; 7/G; 19/U; 4/V; 9/Q; 14/R
Date 4: 32/L; 19/E; 26/M; 27/N; 34/R; 25/S; 30/W; 30/k; 7/e; 25/i; 30/b; 13/h; 2/L; 18/U; 7/W; 9/S
Date 5: 36/D; 20/G; 34/d; 26/I; 10/Y; 27/K; 36/T; 30/T; 26/U; 33/W; 36/n; 29/j; 24/h; 32/c; 5/a; 13/d; 28/b; 5/S; 18/Y; 9/O; 17/P
Date 6: See Figure TRB.15–1
Nest: 27/U

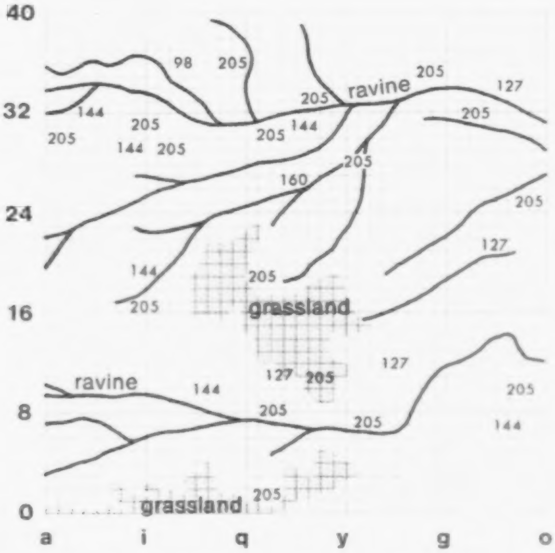


Figure TRB.15–1 Location of birds on date 6. The birds are identified by numbers as follows: 98 = flicker; 160 = solitary vireo; 144 = robin; 127 = scrub jay; 205 = rufous-sided towhee.

8. Compare the population density of scrub jays with that of rufous-sided towhees. Is the carrying capacity of the area the same for these 2 species, or are you unable to tell? Explain your answer.
9. What does the distribution of some of these territories suggest about the habitats in surrounding areas?
10. There is a single record of a rufous-sided towhee at 11/G and a single record of a red-shafted flicker at 21/F. What could account for these single records during the breeding season?
11. There may be some doubt that in a particular area during the breeding season the day-after-day presence of individual birds or the regular occurrence of a singing male indicates a nesting territory. Is there evidence from these territory data that these are indicators for nesting territories? If so, what is it?

For Further Investigation

You can try some actual fieldwork in your own area, preparing field maps and working out territories of local nesting birds. Usually, you can start such studies in late April, and, ideally, they should continue into midsummer. The National Audubon Society, 950 Third Avenue, New York, NY 10022, has a leaflet on how to carry out breeding-bird studies.

Investigation TRB.15 A METHOD FOR STUDYING TERRITORIALITY

The data in this investigation are derived from a study of a brushland, of a grassland, and of a ponderosa-pine area adjacent to a Colorado Springs high school. Parts of both the fieldwork and the analysis of data were carried out by high school students in a National Science Foundation summer science-training program. The study concerned sizes of breeding-bird populations. The complete study was published in *Audubon Field Notes*, December, 1964, pp. 567–568.

In 3 of the 5 species—flicker, robin, and rufous-sided towhee—the sexes can be distinguished in the field even when birds are not singing.

Procedure

When students have finished plotting the dates, the clusters of different numbers represent the bird territories. Students should draw circles around these territories. In some cases, the decision about which group of numbers represents a territory will be arbitrary. In the actual study, more field data were available. And, in actual practice, ornithologists would check their decisions with further field observations. Encourage students to make as reasonable a choice of numbers for territories as possible. Probably not all of them will agree, but neither might two professional ornithologists.

Discussion

1. Generally, larger birds tend to have larger territories. Also, the carrying capacity of an ecosystem is different for different species, and this has an effect on territory size. If, in a particular locality, the carrying capacity for a species is low, a pair of that species generally holds a larger territory there than they would in a more favorable locality.

2. Because different species occupy different ecological niches, territories held by individuals of different species ordinarily overlap.

3. Red-tailed hawks are second-level consumers that require a large territory in which to hunt food. This study area is only a small part of it. The hawks nest elsewhere in their territory.

4. Brushland, with pine woodland next.

5. There might be a limited number of nest trees available. Actually, there is only one good nest tree in the entire plot, a large pine with a dead top, and over the years this is where the flickers have nested.

6. Students should find about 25–27 territories wholly or mostly within the area. Because there are 2 adult birds per territory, the carrying capacity is approximately 50 birds.

7. There is less variety and abundance of food in the winter, not to mention less shelter. During 5 recent winters the average number of rufous-sided towhees has been only 4, all males.

8. The carrying capacity of the area is not the same for the 2 species. The 2 species are of different sizes and occupy different niches, though both occur in brushland. Based on what one can determine here, it would be difficult to decide whether the population of either was less than the carrying capacity would sustain, because carrying capacity is governed by a number of limiting factors. More studies would be needed to determine this.

9. Because some of the territories exist on the boundaries of the plot, one would expect that in such locations similar habitat would occur outside the plot.

10. These may be individuals from outside that, on occasion, invaded the area. Another possibility is that these birds, noted on the first field date, failed to establish territories for one reason or another, or that the observer failed to record these birds on later field trips.

11. The location of nests do fall within some of the postulated territories. Some students might think that locating nests would be an easier way to work out territories than recording singing males. In the case of the rufous-sided towhees, however, though the breeding density was high, only one nest was found. This frustrating experience is common.

Investigation TRB.16 STUDY OF A POND COMMUNITY

Introduction

Ponds have many advantages for the study of aquatic communities. They furnish a variety of habitats, have many relationships with the surrounding land, and are found in many places. Natural ponds usually show the most complex relationships, but artificial ponds are simpler to study and easier to find. If your class has studied a land community, that experience ought to increase their ability to investigate a pond.

Materials

For Part A (per class)

2 wide-mouth screw-top jars about 1000-ml
7 wide-mouth screw-top jars about 4000-ml
13 wide-mouth screw-top jars about 500-ml
No. 3 can, lid smoothly removed
No. 8 mesh sieve
plankton net
plant-grappling bar
trowel
dip net
wire-cloth seine
2 forceps
4 glass-marking pencils
6 plastic bags
6 rubber bands
refrigerator

For Part B (per team; quantities depend on team size)

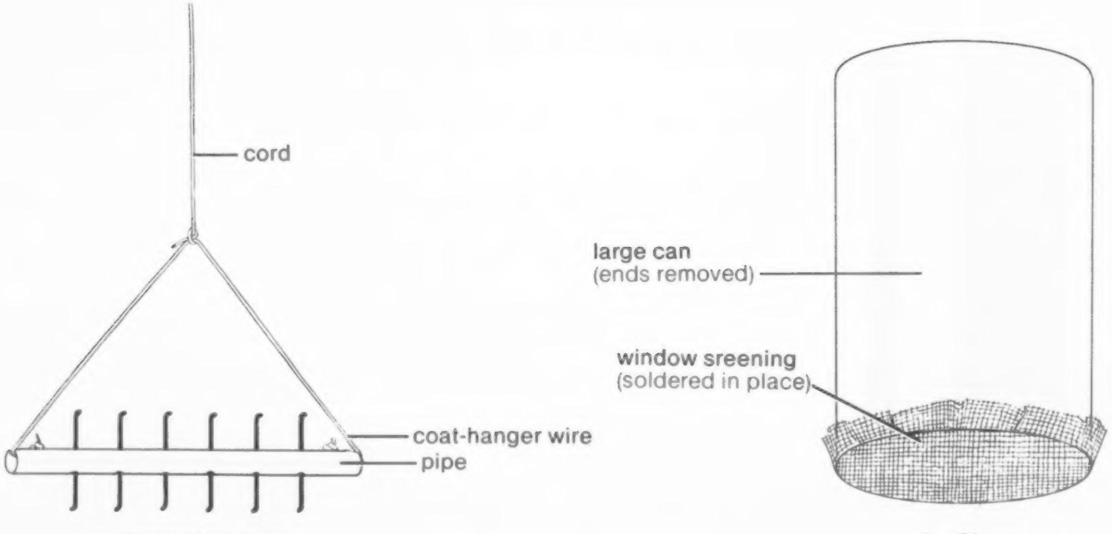
manuals for identification
monocular microscopes
stereomicroscopes
hand lenses
microscope slides
coverslips
dropping pipets
forceps
scalpels
finger bowls

Procedure

Part A—Field Study

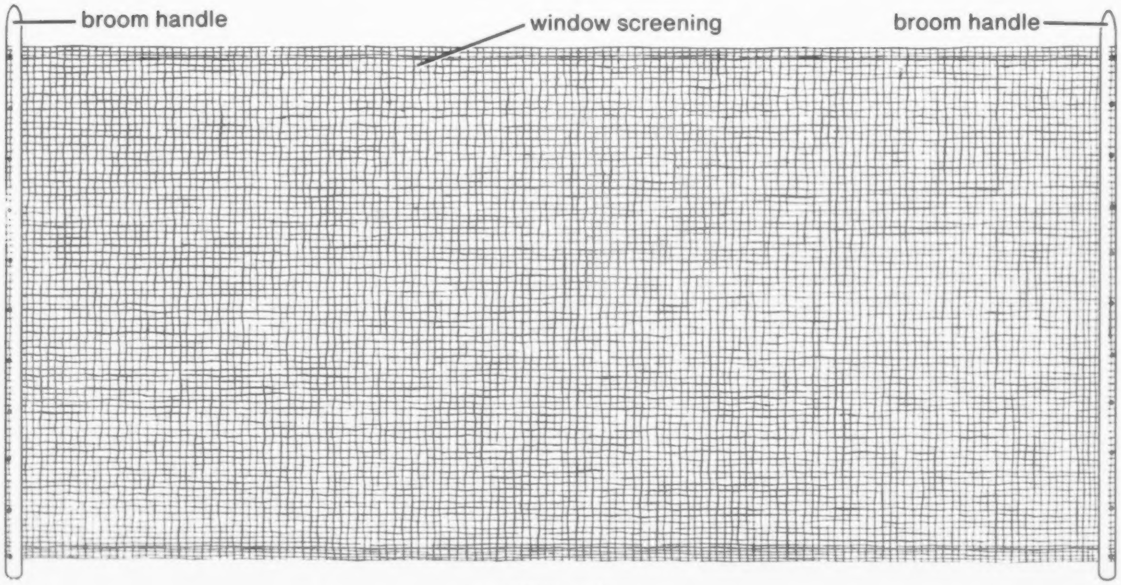
Organize 4 teams: the 1st to study plankton organisms, the 2nd to study the organisms on the bottom of the pond, the 3rd to study large water plants, and the 4th to study large animals. *Do not disturb the environment more than is absolutely necessary. Remember that only a few specimens of each species are needed.*

1. Team 1:
   (a) Before leaving the laboratory, use a glass-marking pencil to label 2 wide-mouth, 1-liter jars as follows: Surface-water zone and Deep-water zone.
   (b) Take the jars and plankton net to a place from which the plankton net can be cast into the water. Place clear pond water in each jar until it is about ⅓ full. Cast the net into the water and pull it through the open-water zone. If the net is pulled rapidly, it will stay near the surface. Do this several times. Then raise the net. You may see a number of tiny organisms in the bottle. Untie the bottle from the net and empty its contents into the jar labeled Surface-water zone. Repeat surface collecting 3 or 4 times.
   (c) To collect organisms in the deep-water zone, allow the net to sink to the desired depth and then pull slowly. Place collections from the deep water in the 2nd jar. If you must wait for other teams, put the jars in the shade until you are ready to leave. If jars are left in sunlight, many of the organisms will die.

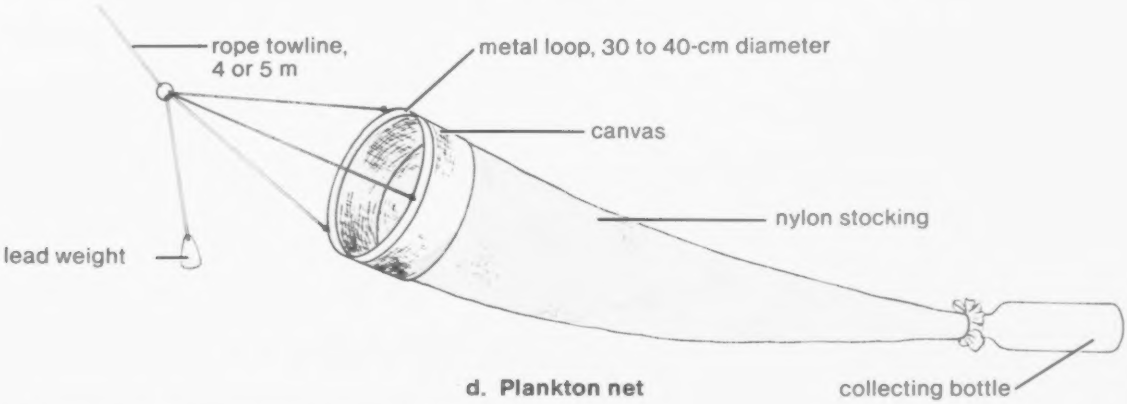

cord
coat-hanger wire
pipe
large can
(ends removed)
window sreening
(soldered in place)

a. Grappling bar

b. Sieve


broom handle
window screening
broom handle

c. Wire seine


rope towline,
4 or 5 m
metal loop, 30 to 40-cm diameter
canvas
nylon stocking
lead weight
collecting bottle

d. Plankton net

TRB.16–1 Some equipment for collecting pond organisms.

2. Team 2:
    (a) Before leaving the laboratory, select three 500-ml jars and three 4000-ml jars. Label 1 jar of each size as follows: Bottom: emergent-plant zone, Bottom: submerged-plant zone, and Bottom: open-water zone.
    (b) Take the jars, a sieve, and a can to the pond. Fill each jar about halfway with clear pond water. With the can, scoop up some mud from among the emergent plants. Dump this mud into the sieve. Shake the sieve in the water until the mud is washed out. Remove dead leaves and sticks. Pick out whatever organisms you find and put these into the appropriate large jar. Carefully scoop up a small sample of the mud and place it in the appropriate small jar. Repeat this procedure in the other two zones.
3. Team 3:
    (a) Before leaving the laboratory, label 6 large plastic bags. Label 2 of the bags Emergent plants, 2 Floating plants, and 2 Submerged plants.
    (b) Take the labeled bags, 6 rubber bands, a trowel, and a plant-grappling bar to the pond.
    (c) Collect a specimen of each kind of plant in each of the 3 plant zones. Whenever possible, collect a whole plant. Roots and underground stems often are important for identification. If the whole plant is too large, collect leaves and flowers or fruits. Put the plants of each zone into separate plastic bags.
4. Team 4:
    (a) Before leaving the laboratory, select ten 500-ml jars. Label 5 of the jars Emergent- and floating-plant zone, and the other 5 Submerged-plant zone. Select four 4000-ml jars, and label 2 Emergent-plant zone and the other 2 Submerged-plant zone.
    (b) Take the jars, a dip net, and a seine to the pond. Have 1 member of the team record animals seen but not collected. This should include all animals that seem to be a part of the pond community, whether they live in the pond or not.
    (c) Use a dip net or the seine to collect the larger animals—fish, crayfish, some of the larger insect larvae, turtles, and snakes. The smaller ones will go through the holes in the collecting equipment.
    (d) Catch the animals in the emergent-plant zone, near the edge of the pond. Put them into the labeled jars. Place insects together in the same jar, with some sticks and leaves for shelter. Place only a few fish together in one jar. Use the smaller jars for specimens that might injure one another. **CAUTION:** ***Be careful in handling animals. Some of the insects as well as larger animals can inflict painful bites.***
    (e) Collect organisms in the submerged-plant zone. Do not collect more than 1 or 2 specimens of each of the larger animals.
5. All teams: When you return to the laboratory, loosen the caps and place the jars in the lower part of the refrigerator or in some other cool place. The organisms will be less active; this should prevent the large ones from eating the small ones.

Part B—Laboratory Study

Each team should study its own collections and report its findings to the class.

You should be able to identify most organisms to the phylum level, many to lower levels. Identifying to the species level is not necessary. The following are useful for the identification of aquatic organisms:

T. T. Macan, 1974, *Freshwater Ecology*, 2nd ed. (New York: Halsted Press).

H. Mellanby, 1975, *Animal Life in Freshwater* (New York: Halsted Press).

D. R. Stamm, 1977, *Underwater: The Northern Lakes* (Madison: Wis.: University of Wisconsin Press).

R. G. Wetzel, 1975, *Limnology* (Philadelphia: W. B. Saunders).

This investigation is not designed as a *quantitative* study. However, some idea of the relative abudance of different kinds of organisms will help you understand the community. Whenever possible, record the number of organisms you identified in the pond community. Listing kinds of organisms in order of abundance might be one method.

1. Team 1: The plankton organisms are mostly microscopic. Use dropping pipets to handle them, slides and coverslips to mount them, and monocular microscopes to observe them.
2. Team 2: Use hand lenses or stereomicroscopes to observe organisms washed from the mud. These will be easier to see in a finger bowl over a piece of white paper. Handle larger organisms with forceps, smaller ones with dropping pipets. Examine the mud in the small jars. Place a small bit of mud in a drop of water on a microscope slide under a monocular microscope.
3. Teams 3 and 4: Hand lenses, forceps, and finger bowls (or porcelain pans) are the only tools that you will need for examining your collections.

Discussion

When you have received the data from all teams, write a description of the pond community. Try to relate all the data.

Consider the niches of the various organisms. To begin with, you can assume that macroscopic green plants are producers. Microscopic organisms are more difficult to decide about. Some consumers may be green because they have eaten algae. The green of some producers may be obscured by other pigments. You can sometimes separate carnivores from herbivores on the basis of structure or behavior. Can you see any relationship between the size of organisms and their relative abundance? If so, what is the relationship and how can you explain it? Finally, consider the relationships between the pond and surrounding communities on the land. How does energy received from the sun flow from the pond community into the land communities? Is there any reverse flow of energy? If so, how does it occur?

Investigation TRB.16 STUDY OF A POND COMMUNITY

CAUTION: *Additional safety precautions are necessary for pond work. Avoid deep ponds.*

Materials

The gallon jars in which pickles and mayonnaise are supplied to cafeterias are suitable for the 4000-ml size. Quart and pint jars usually obtainable from students' homes serve well for the other sizes. A good safety precaution is to crisscross the larger jars with strips of masking tape to reduce shattering if they are dropped.

Those students who are especially interested can easily construct the simple collecting equipment by using the illustrations as a guide.

Procedure

The distance to a suitable pond may be so great that class trips for the fieldwork may be impracticable. In such a case, try to organize a small group of volunteers to do the collecting on a weekend. If the collected material is not crowded and is kept in a refrigerator, it will usually survive 3 or 4 days. All students then can observe, identify, and count the organisms. Divide the class into teams for this purpose. Make a copy of the notes for each student. This assembled information forms the basis for the discussion.

Investigation TRB.17 BIOETHICS: A PROBLEM IN DECISION MAKING

Introduction

Scientific information alone is insufficient for making bioethical decisions. In such decisions, however, biologic information is essential. For example, if prenatal diagnosis shows that a fetus has a genetic disorder, the parents and genetic counselor need to know as much as possible about the disorder, including its genetic base and its potential impact on the physical and mental development of the fetus. In considering possible options and their outcomes, the parents also must consider their own values. Depending on their ethical and religious beliefs, their own upbringing, and the values of their communities, the parents might decide to continue with the pregnancy as if they did not know about the disorder, to try an experimental treatment, or to abort the fetus. In this investigation you will weigh some of the issues involved in making a bioethical decision in a fictitious case.

Procedure

1. Read the following fictitious article that describes a situation involving a genetic disorder and some possible courses of action.

> A young woman, Sarah, is pregnant for the first time. Sarah and her husband, Bob, are both descended from Eastern European Jews, and they are afraid their baby might inherit Tay-Sachs, a recessive disorder that is more common in these people than in the general population. Children who inherit two alleles for Tay-Sachs lack an important enzyme, hexosaminidase A. Without hexosaminidase A, lipids accumulate in nerve cells and brain cells, and destroy nerve tissues. This disorder causes severe retardation and death, usually before the age of four.
>
> Sarah undergoes amniocentesis and learns that her fetus has inherited the Tay-Sachs disorder. In discussing the problem with a genetic counselor, Bob and Sarah learn that at present there is no treatment or cure for Tay-Sachs. Sarah is healthy, so she probably could become pregnant again if she and Bob decide to abort this fetus.
>
> Sarah's obstetrician refers them to a researcher who is producing hexosaminidase A by using techniques of genetic techology. The researcher introduces the appropirate genes into bacteria, cultures the bacteria in large vats, and then extracts the enzyme they have synthesized. Hexosaminidase A produced in this way has not yet been tested for effectiveness in humans, but the researcher estimates there is a 60 percent chance of successfully treating a patient by using the enzyme. If Sarah continues the pregnancy, her child could be treated with hexosaminidase A and the enzyme level could be tested monthly. Treatment might have to be continued for life. The researcher's grant would take care of all the costs of the birth and five years of the experimental treatment.
>
> Sarah and Bob are students and cannot afford extensive medical costs. Although no social stigma would be involved, both their parents are opposed to abortion. Their decision, then, will depend on a variety of factors, including personal, family, and societal values.

2. As a class, you will evaluate the possible actions in this case. Your teacher will assign you to a team representing one of the following roles:
   (a) the fetus
   (b) Bob and Sarah
   (c) Bob's and Sarah's families
   (d) the community
   (e) the researcher
3. Each team will meet to analyze the options from its particular viewpoint. Discussions should consider ethical, as well as biologic, aspects of the actions. Copy the table below in your data book and use it to guide and record your discussion.

Viewpoint of ______________________

ADVANTAGES AND DISADVANTAGES in terms of:	**OPTIONS**		
	no action	**treatment**	**abortion**
Physical pain or mental suffering			
Opportunity for acquisition of new knowledge			
Financial cost			
Legality of action			
Medical/technical difficulty of action			
Ethical difficulty of action			
Other			

4. Each team must develop specific arguments for and against each of the options, and then reach a consensus on the most acceptable option.
5. Choose one person from each team to present the team's findings to the class. Be sure to cover all aspects of each option from the team's viewpoint. Summarize the arguments for and against each option in the table your teacher has drawn on the chalkboard.
6. As a class, determine which option seems the most acceptable. That option will represent a compromise among the various teams and their values. Two biology classes in the same school might reach differing decisions about the same issue.

Discussion

1. To which team were you assigned? Were you able to emphathize with your team's viewpoint? Why or why not?
2. Of the possible options from your team's viewpoint, which one did you personally prefer? Which advantages and disadvantages seemed most important in making your decision?
3. Did you agree with the class consensus? What values influenced your personal vote?
4. Did the class decision coincide with your values? As a citizen, what recourse would you have if you objected to a group decision on a bioethical issue?
5. If you were a member of a review board at the university where the research was being done, which option would you choose?

Investigation TRB.17 BIOETHICS: A PROBLEM IN DECISION MAKING

You may wish to discuss a topic from current news rather than the fictitious case described here. Students are likely to be more interested in a familiar local issue than in the one presented in the procedure. You must be careful, however, to avoid any issue that involves a student or a student's family. You will need to review the necessary biological information before the investigation begins. You may need to modify the tables to fit the topic you select.

The physical arrangement of the classroom is important for these discussions. To establish a conducive physical environment, put chairs around small tables in a random arrangement, move desks into circles, or place stools around lab tables. If you have nothing in your classroom other than bolted-down desks or auditorium seats, find some open space and allow students to sit on the floor. If possible, conduct class in the cafeteria, gymnasium, conference room, student lounge, outdoors or anywhere the environment will allow face-to-face interaction among the students. Remember that you will need to take a portable easel or chalkboard with you.

Be sure the discussion covers all aspects of each option, so that the students clearly see the complexity and conflict in the decision. Draw on the chalkboard a large table like the one below in which the teams can summarize their arguments for and against each option.

Issues such as the example here are potentially controversial. How much controversy will develop depends on many factors: the socioeconomic climate of the community, the religious preference of your students, and the ethics of your students and their parents. The most important factor is how you handle the issues in the classroom. One teacher's method of dealing with controversial issues is described below.

1. Present as much information about the issue as possible. Often the narrow and rigid viewpoint of students is a result of having insufficient, or erroneous, information.
2. Allow all opinions or feelings to be expressed. Do not censor, but, on the other hand, if a student is saying something for shock value alone, point out the inappropriateness of the statement for the discussion.
3. Acknowledge each opinion equally. Do not favor one viewpoint, and encourage a similar accepting attitude among the students. They should feel that they have every right to say what they think if it is a positive contribution to the discussion.
4. Create an open, non-hostile atmosphere in the classroom, not just for this discussion, but at all times.
5. Be careful to keep your personal values out of the discussion, and be ready to assist students in defending differing points of view.

Team	Arguments	OPTIONS		
		No action	**Treatment**	**Abortion**
Fetus	FOR			
	AGAINST			
Bob and Sarah	FOR			
	AGAINST			
Bob's and Sarah's Families	FOR			
	AGAINST			
Community	FOR			
	AGAINST			
Researcher	FOR			
	AGAINST			

Resource Book of Test Items

Jean P. Milani, BSCS, Green Version Revision Coordinator
James L. Koevenig, University of Central Florida, Principal Author

BSCS Production Staff
Anthony A. Hauk
Douglas J. Robert
Katherine A. Winternitz

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Foreword

This sixth edition of the BSCS Green Version has undergone a major reorganization that places greater emphasis on the role of humans in the biosphere. Because of our profound ability to affect all aspects of the biosphere, our future and the future of the earth depend on our understanding of humans as participants in the biological community.

Biology examines all aspects of life: structure, function, behavior, relationships to the environment, and evolutionary history. The study of biology, however, must be interpreted in a social context. Biological problems often are complicated by social factors that preclude use of available technological solutions.

This Resource Book of Test Items has been completely reorganized to match the reorganization of the textbook. Many of the items reflect the interdisciplinary interpretation of biological knowledge. New test items have been written and old items revised as appropriate. In addition, all items have been keyed to specific sections of each chapter.

As with all BSCS materials, the Resource Book of Test Items includes both recall items and inquiry items. BSCS recommends the inquiry items for major emphasis. Even with emphasis on inquiry items, however, paper-and-pencil tasks do not fully or fairly evaluate a student's progress. Written examinations should thus form only part of any approach to evaluation. Recommendations for a broadened base of evaluation appear on subsequent pages of this book, and you are free to pick and choose test items to fit your own objectives.

We earnestly solicit your comments on the test items in this book. We hope the book will be a valuable and useful adjunct to your biology teaching program. It will be made more so if you will communicate to us your experiences with its use. Please send comments to the director at the address below.

Jane Butler Kahle, Chair
BSCS Board of Directors
Purdue University
West Lafayette, Indiana 47907

Joseph D. McInerney, Director
BSCS
The Colorado College
Colorado Springs, CO 80903

How to Use This Resource Book

Biological Science: An Ecological Approach introduces students to major facts and theories in biology and how they were obtained. Science is defined as a considerable body of ideas and related facts. Science also is defined as the processes by which this knowledge is obtained. All biology students should have the opportunity to employ the processes of science and should be able to demonstrate their understanding of basic biological ideas.

This is a resource book of test items that also are available on computer floppy disk. This is not a book of tests. Items are designed to test the objectives in *Biological Science: An Ecological Approach, Sixth Edition*. Some items are simple; others are complex. Some demand reading ability; others hold reading to a minimum. Some ideas are tested by more than one item; such items are phrased differently to appeal to different types of students. Most of the test items measure the knowledge and understanding (comprehension) of biological information and theories. Those items emphasize theories and definitions. Securing data on student progress in understanding science as a process requires a different kind of item. It is possible to teach students the inquiry skills required to work with higher cognitive levels (application, analysis, synthesis and evaluation), but it is much more difficult to assess those skills, especially with multiple choice items. The test items in this resource book identified as AI (Application-Inquiry) will help you evaluate inquiry skills. Remember that an item might measure Knowledge-Understanding in one situation and Application-Inquiry in another, depending on what is taught and how it is taught. Each item in this book has been coded to chapter and section. Items have been provided for all chapters in *Biological Science: An Ecological Approach*. A sufficient number of items has been included so that you can prepare a test containing 20 to 30 items to evaluate the students' understanding of several ideas in a chapter. The items in this book offer enough variety to allow you to choose those that best exemplify the approach you have used to develop understanding of your objectives.

Multiple-Choice Items

The multiple-choice format, which is used in this test book, is a versatile means of gathering data on student performance. Questions can be formulated on nearly any subject and the items can be designed to measure various levels of cognitive ability. (However, multiple-choice items that measure higher cognitive skills are difficult and time-consuming to construct.) Examinations should give students a chance to demonstrate their accomplishment. Out of four items selected from the resource book, three might require recall and one might require reasoning or application. When you select items do not pick them in such a fashion that one question keys the next. This resource book offers enough items in most areas so that problem can be avoided.

To assemble your tests from the resource book, first identify the objectives for which you wish to test. Next identify the subject-matter content and the cognitive ability levels required. Then select the appropriate items. Categorize each question carefully and analyze the level of cognitive ability required. These are given in BSCS, 1978, *Biology Teachers' Handbook*, 3rd ed., chapter 3 (New York: Macmillan Publishing Company). You probably will wish to write additional items to evaluate more completely the material you covered. It is good to write 10–20 percent new items for each test. Each question should be critically edited, and the item must actually test for the concept you want to evaluate.

The following list of rules for multiple-choice items merits review periodically. Use these suggestions as guidelines to ensure that you include relevant and dependable items in your testing program

1. First ask yourself what is being evaluated.
2. Keep each item simple; avoid wordy, involved problems covering several concepts or principles and assorted biological data. Complex introductory statements (called stems) often obscure the actual inquiry skill that is being measured.
3. Fully identify sets of items where several questions refer to a single graph or diagram.

4. Illustrations, graphs, or charts of complex problems should be used only if several questions are asked in order to justify the time required to interpret complex data.
5. An item should be unambiguous; the examinee should not be forced to guess the intent of the item writer.
6. Do not use a variety of synonyms within any one item. Choose the term used in the majority of cases in the classroom situation and stay with it throughout the item.
7. Always use foils (alternate responses) that are plausible. Ridiculous foils reduce the discriminatory ability of that item.
8. Responses should be parallel (homogeneous) in construction and content.
9. The correct response should always be unequivocably correct.
10. Avoid duplicate responses. For instance, if the keyed answer is "all of the following (or above)", all other answers must be correct.
11. Avoid redundancy in the responses by including most of the information in the stem.
12. Avoid obvious clues to the right answer. Each response should be about the same length and gramatically consistent with the stem. Terms such as "always," "never," and "all" should be used with care so they do not give away the correct response.
13. Avoid asking opinion questions such as, "What would you do in a given situation?" Any answer would then be acceptable.
14. In an item calling for a judgment, the authority that is to be considered correct must be made clear.
15. There is little value in items that are difficult merely because the knowledge required is rarely mastered or because that knowledge is trivial.

Selecting Items

To aid in the selection process, you might want to cut individual items from the book and mount them on cards indexed by content. In that way, items can be organized in a fashion congruent with individual teaching styles. Cards then can be selected for any given task and duplicated.

Many questions are in sets that depend on a specific illustration or supplied information. It is not necessary to use all the questions included in any one set. Use only those that apply to the ideas that have been considered in the course. Items selected should present a variety of formats and wordings to assist students in dealing with ideas in several forms.

Each item in this source book is categorized as Knowledge-Understanding or Application-Inquiry, but actual ability level depends on what has gone on in the classroom. Consider the following item:

The rate of oxidation in living cells is controlled by the action of:

A. amino acids.
*B. enzymes.
C. fatty acids.
D. sugars.

This is categorized as Knowledge-Understanding, but it is only a recall item if your students have been taught that the rate of oxidation in living cells is controlled by the action of enzymes. If your students had learned only that all reactions in cells were controlled by enzymes, then the ability level of the item changes to Application-Inquiry, for the student must now apply the recalled fact that all reactions in cells are controlled by enzymes to this specific situation concerning the rate of oxidation, not previously discussed.

The ability-level of an item changes according to the relationship of the question to actual classroom presentation. Items concerned with the highest cognitive levels can be turned into simple recall items if such information is presented to the students in the same form in which it appears in the examination. For example, an Application-Inquiry item becomes a simple Knowledge-Understanding item if the students have been specifically taught the information needed to answer that question. Thus, the categorization of test items according to cognitive levels is neither exact nor fixed, but is conditional, depending on the instruction. Any question instantly degrades to recall if a teacher has made a conscious or unconscious effort to teach the exact material of the test before it is given. Therefore, each item needs to be categorized by the individual teacher, who alone is qualified to assign it to an ability level.

Adapting Items

You may wish to alter the multiple-choice format to a form that best suits a particular group of students. For example, one of the multiple-choice items has as its stem, "Which of the following kinds of organisms would an ecologist predict to be most numerous in an ecosystem?" This is followed by four foils. The same item can be turned into a short-answer question by asking students to predict the kind of organism that would be most numerous in an ecosystem, or by rewriting the item as, "The kind of organism that is either most numerous, or greatest in biomass, in an ecosystem is ______." Multiple-choice items also can be turned into true/false items. Thus a variety of formats can be derived from multiple-choice items in accordance with your objectives.

Items in this book can be altered if that seems appropriate. For most of the questions the number of words has been reduced to a minimum. However, if you or your students feel that an important qualifier has been left out, feel free to add it. Change words that will be difficult for the students in your class to understand.

Do not assume, however, that the complexity of a stem means a higher level of cognition. Many complex stems mask a pedestrian bit of information. Another factor to watch for is that of changing the cognitive category by a change in wording. Many questions that demand application or interpretation can be transformed easily to items that require only recall if you add information or change wording. Many questions present the material of the book in a new setting or in a different fashion. Those questions demand an application or interpretation of previously learned knowledge. Changing those items to reflect the way in which the material was presented will change the intellectual skills needed to solve problems or to apply inquiry abilities.

Preparing Tests

You have the permission of BSCS to reproduce any items in this book for your classroom use. The copyright on this book, however, does cover reproduction of these items for any other use. The items you choose can be typed on ditto masters and the drawings and graphs can be traced. (A mimeograph stylus is especially useful for this purpose.)

If you have a photocopier, you can copy the pages from the book and then cut out the desired items. Tape them directly onto a white sheet of paper to make a master. The question numbers and the correct-answer notation can be removed, and you can substitute your own numbering system. You can prepare an answer sheet or have students use a numbered piece of paper.

A final word on test construction: Student performance and the attainment of learning objectives must be evaluated by more than written skills. Ability to handle ideas, contributions to class discussions, creativity, and other such parameters are difficult to measure by paper-and-pencil examinations, but must be considered when evaluating student progress. Suggestions for developing such means of gathering and interpreting data about student progress appear in the next section of this book.

Administering Tests and Discussing Results

If tests are given immediately after a concept has been taught, then students are most likely to answer questions correctly. This procedure gives students immediate satisfaction when they are right and immediate corrective feedback if they miss an idea. Short tests as part of the lesson give students a chance to use what they have just learned, but they test only short-term memory. Reinforce the learning by discussing each of the responses. When the students are ready, prepare a chapter or section test or an idea test that includes several new (additional) items, but build in success by selecting some items that have been mastered by nearly all students.

The test may be administered as a standard pencil-and-paper test, with the students reading each question and answering it either on a special answer sheet or on a piece of paper that they have numbered, or the questions and the choices can be read to the students, with clarification when necessary, before they record their answers individually on an answer sheet. If questions bear on a specific illustration, you can sketch the illustration or graph on the board or make a transparency for overhead projection. You can then ask questions about the projected diagram so that students understand what is being examined. In this way, students are not penalized for poor or slow reading

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abilities or for not having an extensive reading vocabulary. Such oral techniques may result in higher student scores.

Occasionally, groups of students or laboratory partners can be allowed to pool information to select answers to tests. Each student will bring different talents and insights to discussion sessions held prior to the selection of answers. The grade earned by the group can be assigned to each member of the group.

Every test should be a learning experience. Students are motivated to find out how successful they are on any given examination. As soon as possible (the same or next period, if practical), the examination should be reviewed with the students. If time permits, each question should be discussed orally and students encouraged to indicate why they gave the answers they did. This is often an extremely illuminating experience that shows up defects in the teaching or the examination procedure. When students have approached a problem logically and reasonably and have come up with a wrong answer, it may be more the fault of the test than the students. Tests become a learning experience rather than a grading one when questions are reviewed while student motivation is high.

A Context for Evaluation

For most students the reward for accomplishment is a "good grade." They should not be deprived of this opportunity to realize success. However, goals must be set so that each individual can achieve according to his or her interests and abilities. You need not use the same meterstick to measure each student. You know your class and its individual strengths and weaknesses. Set your objectives accordingly. Tests can increase student comprehension, and they can help you identify concepts that should be retaught.

> A distinction as to kinds of tests and their purposes should be made here. For some quizzes and tests given during the early weeks of the semester, the chief purpose may be to ascertain whether all students have thoroughly mastered certain fundamentals. On such a *mastery test* the expected level of performance by every student would be at or near 100 percent. Those who fall short of 100 percent would be required to do remedial work until 100 percent performance is attained. Obviously, a mastery test does not serve as a ranking device for the purpose of assigning grades (except perhaps in a negative way in that students who attain less than 100 percent are in the unsatisfactory category until 100 percent performance is attained).
>
> At the end of the semester, a substantial *achievement* examination is usually administered for the deliberate purpose of distributing students as widely as possible on a score continuum, ranging perhaps from a 20 percent to a 95 percent performance. Each test item is designed to separate some students from others—those who know or are able to perform from those who do not know or cannot perform. The rigor with which an item achieves this separation is expressed as the *discrimination index* for the item and can be computed in the process of machine-scoring the answer sheets. . . . If the entire test is constructed so that every item will separate some students from others, so that no item in the test will be answered correctly by all students, and so that no item in the test will be missed by all the students, then the test as a whole should produce a range of scores along a continuum. An item usually has a high discrimination index if all or nearly all the upper quarter (actually 27 percent is optimum) of the students answer it correctly and if all or nearly all of the lowest quarter (or 27 percent) answer it incorrectly. If the item also pertains to something that is truly significant in the course in addition to its high discrimination index, it is considered to have high validity, a quality for which perceptive test writers are constantly striving.
>
> The *difficulty index* is simply a measure of the proportion of students who answer an item correctly. A composite of any one index for the individual items gives the index for the test as a whole. (CUEBS Panel on Evaluation and Testing, 1967, *Testing and Evaluation in the Biological Sciences:* Commission on Undergraduate Education in the Biological Sciences, Publication No. 20, pp. 4–1, 4–2)

Test results must be viewed within the context of the total process of evaluation or their meanings are likely to be lost. Testing should not be a solitary, isolated event for the purpose of assigning grades. If you establish valid objectives consonant with the skills and abilities of your students and if your tests measure these objectives, most of your students will be successful. When there is a significant difference between a student's test performance and your assessment of his or her ability, look seriously at your objectives, your methodology, or your evaluation devices.

Test scores will indicate areas that need to be retaught. Students should be aware that "missed ideas" will receive your attention also. Second or even third tests or quizzes should be given before grades are assigned. With analysis it seldom will be necessary to repeat the complete test a second time. To encourage learning, select alternate items or tests with a different format and give your students a second chance to correct missed ideas. Establish with your students the evaluative data base you intend to use to determine grades. Help each student to see that this system encourages a maximum of success and that "good grades" are obtainable by each member of the class.

You can use tests to evaluate your own performance and the adequacy of the materials you have used. If, for example, most students missed an item covering an area you thought had been well developed, your reaction should be that either the materials or the teaching failed to help the students learn that topic. Could the area have been approached in another way with a greater degree of student understanding? Teachers using an examination to ask such questions of themselves will ultimately improve their teaching. Similarly, if students were exposed to certain materials and failed to achieve a given objective, could the materials have been in error? If so, how could they be improved? Or, does a particular segment need more explication by you?

How you interpret test results hinges, in large measure, on the role you assign to testing in the total evaluation of learning. Testing may be thought of as sampling student responses to a set of stimuli—usually questions. Evaluation is a much broader concept.

A useful way to think of evaluation is to consider it an interrelated, three-component process. This involves three central questions for the teacher:

What am I trying to do?
How well am I doing it?
How can I do it better?

The evaluation process can be expanded to the following questions:

What learning should be achieved by students?
To what extent are students succeeding in their learning?
How can more effective learning be realized?
How can the teaching/learning process be improved?
What higher-level goals are now in order?

The last question, of course, brings one back to the first question, and the cyclic continuous nature of the evaluation process becomes apparent.

Data Base for Evaluating Students

Securing a broad data base for evaluating progress is one of the most difficult and important tasks facing any teacher. The task is difficult because the development of effective tests requires that the means and ends of the instructional program be kept constantly in view. Unfortunately, tests, more than well-thought-out objectives and well-designed-and-carried-out lessons, control what students will attempt to learn. That is especially true of the temporary retention of so-called "facts." Specific facts, furthermore, are the easiest things to teach, and their retention is the easiest part of learning to assess. Although facts are indeed important, often they are the small ideas that make up the big ideas in biological science. Those big ideas should receive emphasis because they are the end goals of science education.

To help establish a broader spectrum of data, ask yourself these questions frequently:

Do my students read and comprehend suggested reading material?
Do they notice related articles in newspapers or magazines?
Do they mention related television programs?
Do they anticipate laboratory sessions with eagerness?
Do they gain laboratory skills as the year progresses?
Do they come in at odd times to talk about science?
Do they bring in living materials to use in the classroom?
Does their readiness to enter into class discussion increase as the year progresses?
Does each individual get the opportunity to demonstrate her or his ability to inquire into problems?
Does their competency in discussing substantive ideas improve with time?
Can I find new ways to incorporate this spectrum of data into my evaluation of each student?

Inform students about the criteria you will use in the evaluation process and explain how the criteria will be weighted. The following suggestions are offered to assist you in collecting evaluation data.

- Duplicate a selected newspaper article or ask students to bring in one that presents a local view on issues related to conservation, ecology, public health, or general biology. Help students analyze the article and recognize any biases. Have them suggest ways to check the accuracy of the article, alternative solutions to the problem, or public action that might alleviate the situation.
- Divide the class into groups. Give each group the same discussion problems. Allow them time to read, discuss, and reach conclusions. Have one member of each group take notes on the remarks and conclusions offered. Circulate among the discussion groups. When you have allowed enough time for discussion, bring the class together. Have the reporter from each group present the group's remarks and conclusions. Help the class to realize how different groups can reach different but legitimate points of view.
- Consider criteria such as logical thinking, willingness to examine alternative explanations, and the formulation of sound hypotheses as a basis for evaluation. In these initial activities adjust your expectations to the experiences students have had. Increase your expectations for clarity and precision as the year progresses.
- Show selected films with the sound turned off. Present the visual data in a way that elicits inquiry behavior and/or application of knowledge. The BSCS Single Topic Inquiry Films can be used this way. Groups of students can react to each inquiry posed in the films. (Single Topic Inquiry Films are available on super 8 mm film from Hubbard Scientific Company, Box 104, Northbrook, IL 60062; some are also available in video from Media Design Associates, Inc., P.O. Box 3189, Boulder, CO 80307.)

> Observation can be effective as an evaluation device. Random undirected observation, however, is not as useful as directed systematic observation. One way of directing observation of student attitudes, abilities and skills is to place students in a structured situation. This may reduce spontaneity and validity, but it does enable the instructor to make more objective comparisons since all students may be placed in similar situations. An example of a structured situation which might be used in smaller classes is the seminar-type presentation where a student reports on a laboratory or library investigation and then defends his presentation.
>
> Another way of directing an instructor's observation of students is to use a rating scale, consisting of a list of behavioral traits which are indicators of certain desirable attitudes, abilities, and skills. An instructor can base a certain portion of a student's grade on this scale. Although any evaluation of student behavior is subjective, the scale can provide some degree of objectivity. . . .
>
> The use of a rating scale is time-consuming and not entirely reliable or objective, but it is of value in small classes or laboratory sections. Even if the instructor does not attempt to rate students on all categories, it does remind the instructor that these attitudes and behaviors are important, thus affecting his teaching.
>
> Total evaluation of a student's progress and development should encompass, insofar as possible, a broad spectrum of changes he/she has undergone in knowledge, intellectual abilities and skills, and the concomitant acquisition of attitudes befitting an educated person in the truest sense of the word. The procedures described are by no means prescriptive. Some readers may indeed have devised other equally effective approaches. (CUEBS Panel On Evaluation and Testing, 1967, *Testing and Evaluation in the Biological Sciences:* Commission on Undergraduate Education in the Biological Sciences, Publication No. 20, p. 3–1.)

Assessing Laboratory Skills

To assess laboratory skills, plan simple, interesting investigations that can be done in a series of short steps. These should be related to concepts the class has studied. You may want to put out all the necessary equipment or have students gather the equipment as part of the "test." Rate each student on how accurately and efficiently he or she accomplishes each task. During the year, structure these performance or skill ratings so that you can measure the students' improved competency with laboratory techniques. As a review, periodically offer a laboratory practical test in which each student moves from one lab task to the next and records answers to simple and clear requests at each station.

Investigative laboratory activities, however, are designed to provide students with experience in generating knowledge directly from nature. These activities demand a different type of evaluation.

Provide students with opportunities to make conceptual statements based on observations of natural phenomena and to verify their interpretations through scientific procedures. This aspect of laboratory work also can be tested by a laboratory practical, by paper-and-pencil tests, and by observing and questioning the students as they work in the laboratory and the field.

Consider the following English version of a laboratory practical developed as a part of the Matriculation Examination for BSCS students at the Israeli Science Teaching Centre, Hebrew University, Jerusalem. This example contains elements common to most BSCS investigations. A periodic check of these investigative inquiry skills will help your students place the laboratory activity in a proper perspective. You may find that students who do not do well on pencil-and-paper examinations can demonstrate logical insight to solve problems in the laboratory.

Laboratory Practical Problem

Measuring the Rate of Human Respiration

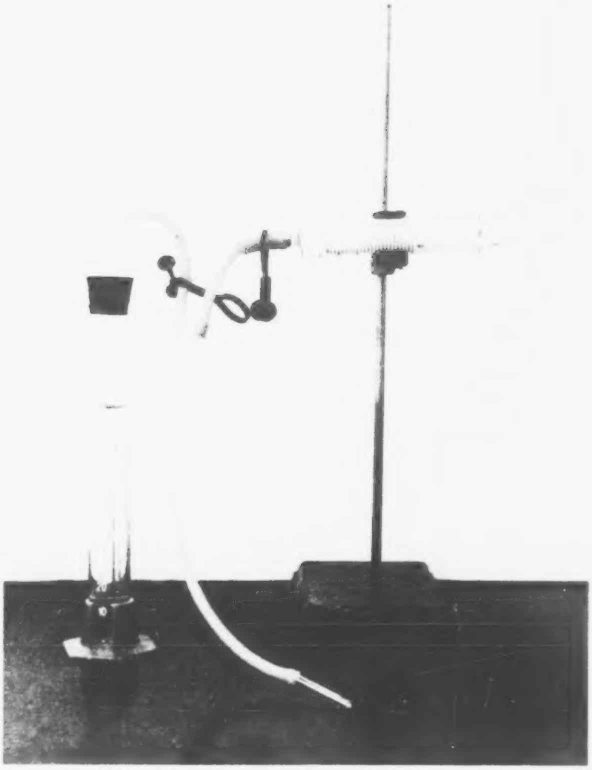
This setup consists of a 100-ml glass syringe attached to a 3-way valve by means of a tube with a clamp. The valve also is attached to a large glass cylinder containing a solution of 0.1 *N* NaOH with phenolphthalein as indicator. A rubber tube, attached to the valve, terminates in a small mouthpiece, which is used to blow expired air into the syringe. (See figure.)

To the student:

1. Examine the experimental setup. Decide how to measure the percentage of CO_2 that you exhale. Do not do anything yet.
2. The following data will help you to understand how the system works.
   - 1 ml 0.1 *N* NaOH contains 4 mg NaOH
   - this quantity combines with 4.4 mg CO_2
   - 1 ml CO_2 has a mass of 2 mg
3. Observe the system and answer the following questions.
   - What is the function of the syringe?
   - What is the function of the NaOH?
   - What is the function of the phenolphthalein?
   - How many mg of CO_2 are measured by this system?
   - How many ml of CO_2 are measured by this system?
4. Write, briefly, how you would perform the experiment. Show your statement to the instructor.
5. After approval, perform the experiment and write the results.
6. If you repeated the experiment 2 more times, would you get the same results in all 3 runs? Why or why not? Explain your hypothesis.
7. Test your hypothesis by doing the experiment. What are the results?
8. How can you intentionally change the results of the experiment? Explain your suggestion.
9. What are your conclusions from these experiments?
10. If a friend of yours performed the experiment, would the results be the same? Explain.
11. Disconnect the syringe from the system, using the clamp on the tube. Answer the following questions without performing any additional experiments.
    - Can you differentiate, using the small system, between 3 air samples: inhaled air, exhaled air, and residual air?
    - How would these 3 samples be different from each other?
    - How can you differentiate among them?
    - What variable is measured in this experiment?

Instructor's Guide: Testing Procedure and Evaluation of Responses

1. Check whether students understand how the system works and the underlying principle. Do this before allowing the students to start with the actual experiment by reading the answers to questions 3 and 4. When required, guide the students but take off credit in proportion to the amount of guidance supplied.
2. Students are expected to understand the need for several measurements because of two unrelated reasons: measuring errors and differences in the percentages of CO_2 caused by actual differences in the air samples.
3. The results can be altered in various ways; e.g., performing 20 knee bends before the investigation.
4. The answer to question 10 requires application of the results in answer 7.



5. In the last item, students are expected to propose distinguishing among the various air samples by the different percentages of CO_2. Since they are not allowed to use the graduated injectors, the best way to make the differentiation would be to measure the length of time for color to change (neutralization).

Analysis of Tests

Test analyses can be very useful to the classroom teacher. If most students missed all or nearly all the questions on a topic, then there was a problem with either the instruction or the testing on that topic. Examination of the difficulty index for each item reveals which ones are too easy (85%) and which are too difficult (25%), and hence should be either modified or eliminated. Difficulty indices can further be generated for each choice in an item: you do not want students to select wrong responses more often than the correct response, nor do you want responses that are never selected by any students.

The discrimination index gives some idea of how well your test questions distinguish between students who know and students who don't know. An item with a negative discrimination index tells you that more "good" students chose wrong responses than did "poor" students. Examination of discrimination indices for each response in each question can give you insight into student misunderstandings, or into flaws in the questions themselves.

The class mean (average) and range for a test indicate general accomplishment. In a large class the scores for a 4-response multiple-choice test might range from 25 to 100% correct. The mean will probably be between 55 and 65% correct. If the mean is below 50% the students will become frustrated and discouraged. If the mean is above 75% then the test probably hasn't separated out the students in the top third of the class. Likewise, if the range is small (say from 50 to 70%), then the test has not separated out the students.

The following paragraphs summarize the procedures for calculating descriptive and item-analysis data. If you desire more information on testing and evaluation procedures, see chapter 3 in the BSCS *Biology Teachers' Handbook* and P. B. Diederich, 1973, *Short-Cut Statistics for Teacher-Made Tests* (Princeton, NJ: Educational Testing Service).

The minimum number of students necessary for meaningful and valid item-analysis data is 20 to 30. The mean is simply the sum of all students' scores divided by the number of scores.

$$\text{Mean} = \frac{\text{sum of all scores}}{\text{total number of scores}}$$

The range is simply the difference between the highest score in the class and the lowest. The highest and lowest scores are generally reported with this figure.

The calculation of item analysis (difficulty and discrimination indices for each item) is tedious and time-consuming; however, some short-cuts can be taken.

Because your instruction methods may vary in different classes, it probably would be more helpful to perform the item analysis separately for each class. You may, however, pool the answer sheets from one test that was administered to several classes. The following is a sequence that you can follow in calculating item-analysis data.

ITEM NUMBER 5. When a nerve connected to an isolated heart is stimulated, the rate of contraction slows. It is reasonable to conclude that the heart

*(A) responds to nervous control.
(B) requires nerve stimulation to speed it up.
(C) is controlled by nerve stimulation only.
(D) responds differently outside the body than in it.

Date used ____________________

ITEM DATA

	Choices			
	*A	B	C	D
High group	16	0	0	1
Low group	6	4	2	1
Difficulty				
Discrimination index				

First, rank the papers in order from the highest to the lowest score. If you have pooled the answer sheets from several classes and the total number is quite large, take the top 27 percent and the bottom 27 percent of the answer sheets and randomly choose 50 papers from each group for the calculations. If the total number of answer sheets is between 50 and 90, the highest 25 papers and the lowest 25 papers can be used. If the total number of students is less than 50, the upper and lower thirds can be used.

It is a good idea to use a single 4″ × 6″ or 5″ × 8″ card for each item, arranged more or less as follows: For each item, tabulate the number of students in the High Group that selected each choice and record this on the card. Do the same for the Low Group. This can be done outside class by you or the students.

Difficulty

The difficulty of choices is measured by the percentage of students responding to each choice. To calculate the difficulty, divide the total number of students responding to each choice (High Group plus Low Group) by the total number of students responding. In equation form, this is:

$$\text{Difficulty of choice} = \frac{\begin{array}{l}\text{number of}\\ \text{High-Group}\\ \text{students who}\\ \text{selected the}\\ \text{choice}\end{array} + \begin{array}{l}\text{number of}\\ \text{Low-Group}\\ \text{students who}\\ \text{selected the}\\ \text{choice}\end{array}}{\text{total number of students}}$$

Consider the following data from a class of 30 students:

The difficulty for choice "A" would be

$$\frac{16 + 6}{30}, \text{ or } \frac{22}{30}, \text{ or } 73.3\%.$$

The difficulty for choice "B" would be

$$\frac{0 + 4}{30}, \text{ or } 13.3\%.$$

The difficulty for choice "C" would be

$$\frac{0 + 2}{30}, \text{ or } 6.7\%.$$

The difficulty for choice "D" would be

$$\frac{1 + 1}{30}, \text{ or } 6.7\%.$$

Discrimination Index

To calculate the discrimination index, subtract the number of students in the Low Group responding to a given choice from the number of students in the High Group responding to that choice. Divide this figure by one-half of the total number of students. In equation form, this is:

$$\begin{array}{l}\text{Discrimination}\\ \text{index of choice}\end{array} = \frac{\begin{array}{l}\text{number of}\\ \text{High-Group}\\ \text{students who}\\ \text{selected this}\\ \text{choice}\end{array} - \begin{array}{l}\text{number of}\\ \text{Low-Group}\\ \text{students who}\\ \text{selected this}\\ \text{choice}\end{array}}{1/2 \text{ total number of students}}$$

With the use of the previous data:

The discrimination index for choice "A" would be

$$\frac{16 - 6}{15}, \text{ or } \frac{10}{15}, \text{ or } 0.67.$$

The discrimination index for choice "B" would be

$$\frac{0 - 4}{15}, \text{ or } -0.27.$$

The discrimination index for choice "C" would be

$$\frac{0 - 2}{15}, \text{ or } -0.13.$$

The discrimination index for choice "D" would be

$$\frac{1 - 1}{15}, \text{ or } 0.0.$$

Because the discrimination index for an item is the discrimination index for the correct response, you could take a shortcut by calculating only the index for the correct response.

A positive item-discrimination index indicates that more high-scoring students are responding correctly to that item than low-scoring students. A negative index means just the opposite. The completed Item Data card for the question about nerve and heart function is shown below.

ITEM DATA	Choices			
	A	B	C	D
High group	16.00	0.00	0.00	1.0
Low group	6.00	4.00	2.00	1.0
Difficulty	73.30	13.30	6.70	6.7
Discrimination index	0.67	−0.27	−0.13	0.0

We hope you will participate in our continuing efforts to improve this book by providing BSCS with information concerning your testing and evaluation programs. Copies of tests you have produced and used, and statistical data (for example, a copy of the 4″ × 6″ card for each item you have used) for such tests would be gratefully received if sent to BSCS, The Colorado College, Colorado Springs, Colorado 80907, Attn: GV6.

Chapter 1
The Web of Life

1. The world community, together with the abiotic environment in which it lives, is called the:

   A. abiotic world.
   B. atmosphere.
   C. biosphere.
   D. world habitat.

   (1.1, C)

2. An example of a question that can be answered by biological investigation is why people who live in the same neighborhood have different:

   A. ideas.
   B. blood types.
   C. family sizes.
   D. friends.

   (1.1, B)

3. The biological term for a living thing is:

   A. creature.
   B. individual.
   C. living being.
   D. organism.

   (1.1, D)

4. What do ecologists study?

   A. all of the following
   B. checks and balances in populations
   C. feeding interactions of organisms
   D. how the living and nonliving parts of the environment affect organisms

   (1.1, A)

5. The food relationships among all organisms that share the same environment are known as a food:

   A. chain.
   B. pyramid.
   C. system.
   D. web.

   (1.2, D)

6. The energy pathway from grass to cow to human being is known as a:

   A. food chain.
   B. food energy pyramid.
   C. food web.
   D. web of life.

   (1.2, A)

7. Energy is stored for long periods of time in organisms as:

   A. chemical energy.
   B. electrical energy.
   C. light energy.
   D. mechanical energy.

   (1.2, A)

8. Which of the following is a producer-consumer relationship?

   A. Flies are eaten by frogs.
   B. Grass is eaten by rabbits.
   C. Mushrooms are eaten by people.
   D. Rabbits are eaten by foxes.

   (1.2, AI, B)

9. Living things that convert light energy into the chemical energy of organic compounds are called:

   A. consumers.
   B. herbivores.
   C. decomposers.
   D. producers.

   (1.2, D)

10. First- and second-order consumers are usually known as:

    A. carnivores and omnivores.
    B. decomposers and omnivores.
    C. herbivores and carnivores.
    D. omnivores and herbivores.

    (1.2, C)

11. In almost all ecosystems, energy is supplied by the:

A. animals.
B. decomposers.
C. plants.
D. sun.

(1.2, D)

12. On land or in water, bacteria and fungi are the most important:

A. decomposers.
B. predators.
C. prey organisms.
D. producers.

(1.2, A)

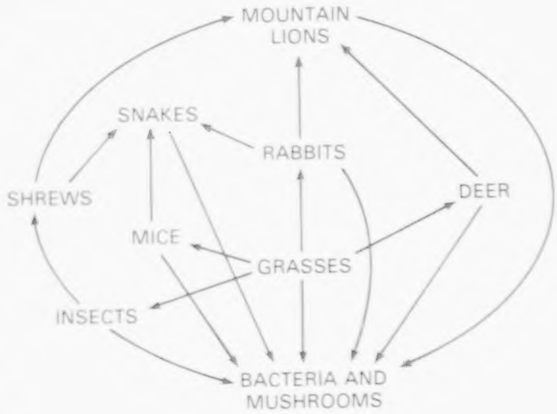
13. An organism that cannot survive in the dark is probably a:

A. decomposer.
B. first-order consumer.
C. producer.
D. second-order consumer.

(1.2, C)

The next ten items are based on the following diagram.

(1.2, AI)



14. This kind of diagram is called a food:

A. chain.
B. energy pyramid.
C. energy flow.
D. web.

(D)

15. The producers in the diagram are:

A. bacteria and mushrooms.
B. grasses.
C. insects, mice, and deer.
D. mountain lions.

(B)

16. The pathway grasses→deer→mountain lions is called a food:

A. chain.
B. energy pyramid.
C. energy flow.
D. web.

(A)

17. How many herbivores are shown?

A. 1
B. 2
C. 3
D. 4

(D)

18. The decomposers in the diagram are:

A. bacteria and mushrooms.
B. grasses.
C. mountain lions.
D. shrews and snakes.

(A)

19. How many carnivores are shown?

A. 1
B. 2
C. 3
D. 4

(C)

20. How many prey are shown?

A. 3
B. 4
C. 5
D. 6

(C)

21. How many predators are shown?

A. 3
B. 4
C. 5
D. 6

(A)

22. Productivity for the diagrammed relationships is measured for the:

A. bacteria and mushrooms.
B. grasses.
C. mice, rabbits, and deer.
D. mountain lions.

(B)

23. The measure of productivity is based on the source of energy for the diagrammed relationships, namely the:

A. bacteria and mushrooms.
B. grasses.
C. soil in the ecosystem.
D. sun.

(D)

---

24. Which might help control a rabbit population?

A. all of the following
B. availability of food
C. diseases
D. predators or animals that eat rabbits

(1.3, AI, A)

25. Which best describes the living world?

A. constantly changing and unbalanced
B. constantly changing yet balanced
C. unchanging (static) and balanced
D. unchanging (static) yet unbalanced

(1.3, B)

26. Which kind of energy can be directly used by all living organisms?

A. chemical energy
B. electrical energy
C. heat energy
D. light energy

(1.4, A)

27. All biological activity directly involves the use of:

A. chlorophyll.
B. energy.
C. muscle.
D. sunlight.

(1.4, B)

28. What is the ultimate source of energy for the biosphere?

A. chemical energy
B. electrical energy
C. heat energy
D. light energy

(1.5, D)

29. Which of these sequences describes the pathway of energy through living things in their environment?

A. chemical energy→light energy→heat
B. heat→chemical energy→light energy
C. heat→light energy→chemical energy
D. light energy→chemical energy→heat

(1.5, D)

30. The energy that is passed along from organism to organism in a food chain is:

A. chemical energy.
B. heat energy.
C. light energy.
D. nuclear energy.

(1.5, A)

31. A farmer started colonies of rats and mink hoping to feed rats to the mink and skinned mink to the remaining rats, thereby getting mink skins for nothing. Is this possible?

A. Yes, because the system would be in balance.
B. Yes, because energy lost feeding rats to mink would be regained feeding mink to rats.
C. No, because second-order consumers cannot feed on each other.
D. No, because much of the food energy is lost as heat.

(1.5, D)

32. If you were marooned on an island with only a limited amount of corn and chickens to eat, your best strategy would be to:

A. eat the chickens, then the corn.
B. eat the corn, then the chickens.
C. feed the corn to the chickens, and eat the chickens.
D. feed the corn to the chickens, eat the chickens' eggs, then eat the chickens.

(1.5, AI, A)

33. What eventually happens to energy that enters a food web? It is:

A. converted to chemical energy.
B. lost as heat.
C. recycled by decomposers.
D. reused in photosynthesis.

(1.5, B)

34. Which best describes the path of energy in a community? It is:

A. converted to heat as it passes from organism to organism.
B. converted to matter by photosynthesis and stored as plant material.
C. cycled and reused by organisms in food chains.
D. used up by organisms in food webs.

(1.5, A)

35. Why is urea considered to be an organic compound?

A. It contains carbon atoms.
B. It contains water molecules.
C. It is made by organisms.
D. It is *not* an organic compound.

(1.6, A)

36. Of the 100+ different elements found on earth about how many commonly make up organisms?

A. 3
B. 30
C. 60
D. all of them

(1.6, B)

37. Which of the following cannot be cycled by organisms?

A. calcium
B. carbon
C. energy
D. water

(1.6, C)

38. In a food chain, matter differs from energy in that the:

A. energy can be changed.
B. energy can be cycled.
C. matter can be changed.
D. matter can be cycled.

(1.6, D)

39. Organic compounds differ from inorganic compounds in having:

A. carbon atoms.
B. carbon chains.
C. chemical bonds.
D. chemical energy.

(1.6, B)

40. Which best describes the interrelationships between organisms in the biosphere? They:

A. are in delicate balance.
B. are independent of human activities.
C. involve only animals.
D. involve only direct contact between organisms.

(1.7, A)

41. Which is *not* true of the biosphere? It:

A. extends into the air (atmosphere).
B. extends to the ocean bottom.
C. includes all organisms.
D. is a thick layer.

(1.7, D)

42. A hypothesis is most valuable in biology when it can be tested by:

A. consensus of opinion.
B. debate among biologists.
C. observation and experimentation.
D. review of available data.

(1.8, AI, C)

43. The factor that is being investigated in an experiment is called the:

A. control.
B. experimental data.
C. experimental variable.
D. outcome.

(1.8, C)

44. The results of an experiment are most likely to be caused by the factor being investigated when other known factors are:

A. controlled.
B. identified.
C. measured.
D. observed.

(1.8, A)

45. The different factors that may affect the results of an experiment are called:

A. measurements.
B. outcomes.
C. procedures.
D. variables.

(1.8, D)

46. Beliefs and values are appropriate subjects for:

A. biological investigation.
B. personal decisions.
C. quantitative observations.
D. testable hypotheses.

(1.8, B)

47. Which of the following pairs of terms in biology mean the same thing?

A. data and facts
B. hypotheses and theories
C. measurement and prediction
D. observation and opinion

(1.8, AI, A)

48. Which describes science?

A. all of the following
B. It is a collection and organization of facts.
C. It is a continuous process of inquiry.
D. It is a way of obtaining facts.

(1.8, A)

49. Which best describes a hypothesis?

A. a conclusion made from data obtained by an experiment
B. an explanation of an observation
C. an observation of the living world
D. facts about an organism or phenomenon

(1.8, B)

50. Preliminary observations about a biological problem may lead to a suspected relationship that can be tested by experiment and further observation. This suspected relationship is called a:

A. chance factor.
B. hypothesis.
C. theory.
D. variable.

(1.8, B)

51. Most biological events result from an interaction of many factors. In an experiment these factors are called:

A. controls.
B. observations.
C. procedures.
D. variables.

(1.8, D)

52. To approach a problem, the most likely steps (in the order a biologist would take them) are:

A. conclusion, experiment, hypothesis.
B. experiment, conclusion, observation.
C. hypothesis, observation, experiment.
D. observation, hypothesis, experiment.

(1.8, D)

53. Most biological events result from an interaction of many factors. In an experiment these factors are called:

A. controls.
B. observations.
C. procedures.
D. variables.

(inv. 1.3, D)

54. Qualitative and quantitative data differ in whether they require:

A. controls.
B. measurement.
C. observation.
D. verification.

(inv. 1.3, B)

55. In an experiment, a group of organisms that are observed under their normal environmental conditions for comparison to another group for which some condition has been changed, is called a:

A. base group.
B. biotic group.
C. control group.
D. data group.

(inv. 1.3, C)

56. In an experiment, a control is an:

A. experimental variable.
B. independent observer.
C. observed result.
D. untested comparison group.

(inv. 1.3, D)

The next five items refer to the following chart. Four groups of mice were studied for the effects of two substances on their growth. Substances X and Y were injected in oil.

(inv. 1.3, AI)

Group	**Treatment**	**Average weight gain of mice after 6 weeks**
I	Injection of X + oil	28.3 grams
II	Injection of Y + oil	24.7 grams
III	Injection of oil	25.2 grams
IV	No injection	24.9 grams

____ 57. How many experimental groups of mice were injected?

A. 1
B. 2
C. 3
D. 4

(B)

____ 58. How many control groups were formed?

A. 0
B. 1
C. 2
D. 3

(C)

____ 59. How many control groups were injected?

A. 0
B. 1
C. 2
D. 3

(B)

____ 60. Which substance produced a marked effect on growth?

A. substance X
B. substance Y
C. substances X and Y
D. oil

(A)

____ 61. How many experimental variables were being tested?

A. 1
B. 2
C. 3
D. 4

(B)

Chapter 2
Populations

1. Individuals are difficult to distinguish in a population of:

   A. grass.
   B. people.
   C. sheep.
   D. bacteria.

   (2.1, AI, A)

2. Which best defines a population? The number of:

   A. biology students in high school
   B. organisms in a defined area
   C. types of organisms in a defined area
   D. zebras in East Africa in 1982

   (2.1, D)

3. The number of individuals of one kind that live in the same area at the same time is defined as a:

   A. carrying capacity.
   B. population.
   C. rate of increase.
   D. sample.

   (2.1, B)

4. All the members of one species that live in the same place at the same time make up a:

   A. biome.
   B. community.
   C. ecosystem.
   D. population.

   (2.1, D)

5. Populations are made up of:

   A. communities.
   B. ecosystems.
   C. individuals.
   D. species.

   (2.1, C)

6. The rate at which reproduction increases a population's size is called:

   A. density.
   B. mortality.
   C. motility.
   D. natality.

   (2.1, D)

7. You would expect to find that emigration and immigration rates are zero for a population of:

   A. aphids on plants.
   B. birds in a forest.
   C. fish in a pond.
   D. mice in a field.

   (2.1, C)

8. The population changes that tend to decrease a population's size are:

   A. emigration and mortality.
   B. emigration and natality.
   C. immigration and mortality.
   D. immigration and natality.

   (2.2, A)

9. The rate of increase in the size of the world's human population can be calculated from the difference in:

   A. emigration over natality.
   B. immigration over mortality.
   C. natality over immigration.
   D. natality over mortality.

   (2.2, D)

10. The population changes that tend to increase a population's size are:

    A. emigration and mortality.
    B. emigration and natality.
    C. immigration and mortality.
    D. immigration and natality.

    (2.2, D)

11. A population tends to increase in numbers as the result of:

    A. emigration and natality.
    B. emigration and mortality.
    C. immigration and natality.
    D. immigration and mortality.

    (2.2, C)

Questions 12 through 15: Use the following terms as responses. Any one term may be used more than once or not at all.

(2.2)

KEY A. emigration
B. immigration
C. mortality
D. natality

____ 12. The number of organisms dying in a population within a given time is called:

(C)

____ 13. The number of organisms moving out of an area where that population lives is called:

(A)

____ 14. Fifteen fawns are born in a deer population in Florida. This is an example of:

(D)

____ 15. The rate of reproduction in a population is called:

(D)

---

16. Doors that swing outward but not inward enabled mice to leave a population but not to enter it. An increase in population numbers followed as the result of an increased:

    A. emigration.
    B. immigration.
    C. mortality.
    D. natality.

    (2.2, D)

17. The rate of change in a population's size is expressed in terms of:

    A. density of population and space occupied.
    B. numbers of individuals and space occupied.
    C. numbers of individuals and time.
    D. space occupied and time.

    (2.2, C)

18. Why does the human population have such a large impact on the earth's plants and animals?

    A. all of the following
    B. Our population is large and increasing.
    C. We use high amounts of resources.
    D. We return resources as unusable wastes.

    (2.3, A)

19. Why is the human population on earth increasing?

    A. Human mortality exceeds natality.
    B. Human natality exceeds mortality.
    C. The earth's resources are increasing.
    D. It is *not* increasing.

    (2.3, B)

20. Today humans trade food for space. More land is taken out of agriculture and given to new streets, shopping centers, homes, and industries. This leaves less agricultural land to feed increasing numbers of people. Assuming that this cannot go on indefinitely, the world's greatest problem is becoming:

    A. depletion of energy resources.
    B. overpopulation.
    C. pollution.
    D. safe waste disposal.

    (2.3, AI, B)

21. The world human population is increasing by the rate at which:

    A. emigration exceeds immigration.
    B. immigration exceeds emigration.
    C. mortality exceeds natality.
    D. natality exceeds mortality.

    (2.3, D)

22. Which domestic use of water is largest?

A. bathing or showering
B. brushing your teeth
C. cooking a meal
D. flushing the toilet

(inv. 2.2, A)

23. How can you reduce your direct use of water?

A. all of the following
B. Take shorter showers.
C. Wash clothes only when you have a full load.
D. Don't let the water run while brushing your teeth.

(inv. 2.2, A)

24. The production of which food item requires the greatest amount of water?

A. 1 egg
B. 1 kg of beef
C. 1 kg of sugar
D. 1 orange

(inv. 2.2, B)

25. Which of the following is a part of the biotic environment?

A. air
B. sunlight
C. vegetation
D. weather

(2.4, C)

26. How does weather affect plants and animals? It:

A. affects only special organisms.
B. often is a limiting factor.
C. seldom is a limiting factor.
D. does *not* affect them.

(2.5, B)

27. Which affects the space an organisms needs?

A. all of the following
B. availability of nutrients
C. population density
D. size of the organism

(2.6, A)

28. "Eleven grasshoppers per square meter in Douglas County, Nebraska, this year" is an expression of:

A. density.
B. natality.
C. population explosion.
D. rate of increase.

(2.6, AI, A)

29. In the equation $D = N/S$, which expresses density of population, the N stands for:

A. natality.
B. number of individuals.
C. rate of change.
D. time.

(2.6, AI, B)

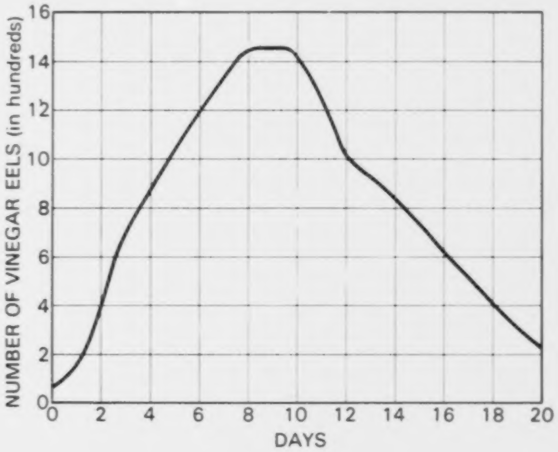
30. Students captured 9, 4, and 7 beetles of the same kind in three different 1 m^2 plots of forest floor. Their calculation of the population of these beetles in the forest will be based on:

A. carrying capacity.
B. homeostasis.
C. relative density.
D. sampling.

(2.6, AI, D)

The next five items refer to the following graph of a population of vinegar eels.

(inv. 2.3, AI)



31. On which day was the rate of change for population density zero?
    - A. Day 1
    - B. Day 5
    - C. Day 9
    - D. Day 12

    (C)

32. On which day did the rate of change of density increase most?
    - A. Day 1–2
    - B. Day 2–3
    - C. Day 6–7
    - D. Day 8–9

    (B)

33. On which day did the rate of change of density decrease most?
    - A. Day 9–10
    - B. Day 11–12
    - C. Day 14–15
    - D. Day 19–20

    (B)

34. What was the average rate of decrease each day for the 11 days from the end of the 9th day to the 20th day?
    - A. 1250 individuals
    - B. 430 individuals
    - C. 250 individuals
    - D. 115 individuals

    (D)

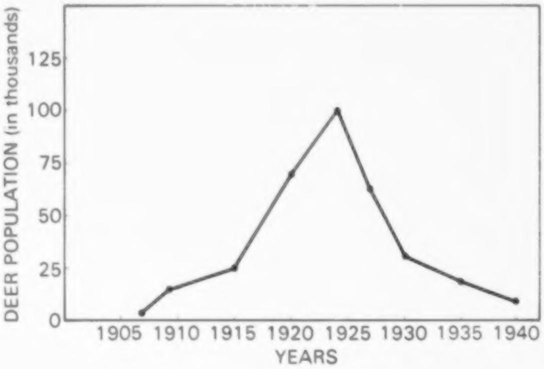
35. If the same average rate of decrease continued, how many days passed after Day 20 before the population ceased to exist?
    - A. 2
    - B. 4
    - C. 6
    - D. 8

    (A)

The next six items refer to a hypothetical study paralleling an actual one carried out in the Kaibab National Forest.

(inv. 2.3, AI)

A 2850 km² area supported populations of deer and wolves. In 1915, a program was started to protect the deer by eliminating the wolves. By 1925, the wolves had been completely eliminated from the area. Yet the protected deer population, which had reached 100,000 in 1924, began to drop sharply as shown on the graph below.



36. At the deer population's peak in 1924, its density had reached approximately:
    - A. 5 individuals per km².
    - B. 15 individuals per km².
    - C. 25 individuals per km².
    - D. 35 individuals per km².

    (D)

37. Those who started the program to protect the deer apparently failed to anticipate:
    - A. effects on aging on deer.
    - B. effects of fires and drought.
    - C. competition for food from other herbivores.
    - D. overpopulation and starvation of deer.

    (D)

38. The wolves played an important role in keeping the deer population:

A. free of aging individuals.
B. limited in total numbers.
C. migrating between feeding areas.
D. out of replanted forest areas.

(B)

39. The population crash continued because grasses, shrubs, and young trees had been:

A. killed by the starving deer.
B. overfertilized by deer wastes.
C. set back by fire and drought.
D. trampled under the deer's hooves.

(A)

40. A permanent solution to the problem appeared to require:

A. bringing in winter food supplies.
B. enlarging the land area.
C. reintroducing the wolves.
D. removing other herbivores.

(C)

41. This study suggests that an ecosystem must have:

A. balanced year-round food supplies.
B. carnivores to prey on herbivores.
C. herbivores as prey for carnivores.
D. producers *and* consumers.

(B)

---

42. Which major factor will affect the future health of people the most? An increase in:

A. the food resources
B. the life expectancy
C. the use of antibiotics
D. water contaminated by toxins or wastes

(2.9, D)

43. Producers get their nutrients from:

A. consumers.
B. plants.
C. the abiotic environment.
D. the biotic environment.

(2.10, C)

44. All substances except air and water that an organism needs from its environment are called:

A. elements.
B. minerals.
C. nutrients.
D. sources.

(2.10, C)

45. Providing each person with a daily average of 1000 kcal from meat only would result in:

A. famine.
B. malnourishment.
C. proper nourishment.
D. undernourishment.

(2.11, A)

46. Providing each person with a daily average of 4000 kcals from rice only or corn only would result in:

A. famine.
B. malnourishment.
C. proper nourishment.
D. undernourishment.

(2.11, B)

47. What is a food calorie? A measure of:

A. energy in food
B. essential elements in food
C. food quality
D. the amount of food

(2.11, A)

48. Widespread famine has occurred in which continent for the past 10 years and will continue in the future?

A. Africa
B. Asia
C. Europe
D. South America

(2.11, A)

49. Which is responsible for widespread famine in Africa?

A. all of the following
B. drought
C. population explosion
D. soil erosion

(2.11, A)

50. Which is the most energy efficient way of getting food?

A. fishing
B. hunting and gathering nuts, berries, etc.
C. mechanized farming
D. nonmechanized farming

(2.11, D)

51. What is wrong with our highly mechanized farming?

A. It is an energy-losing system.
B. It is reliant on human labor.
C. It is too efficient—it raises too much food.
D. Nothing.

(2.11, A)

52. Most people in the United States eat a diet that provides food energy in excess of:

A. 3,000 kcals a day.
B. 4,000 kcals a day.
C. 5,000 kcals a day.
D. 6,000 kcals a day.

(2.11, A)

53. Which best illustrates homeostasis in a population?

A. a rapid increase in the Swedish lemming population resulting in a mass migration to the ocean
B. stable deer population in a Rocky Mountain valley resulting from emigration, natality, and mortality
C. the growth of the human population due to the control of diseases
D. the rapid increase then decline of reindeer on St. Paul Island

(2.13, AI, B)

54. Which best describes homeostasis in humans? It:

A. has been disrupted.
B. is finely balanced.
C. is functioning perfectly.
D. never existed.

(2.13, A)

55. An established population that fluctuates in size as the carrying capacity of its environment varies is said to be exhibiting:

A. ecological extinction.
B. ecological homeostasis.
C. growth decline.
D. overcrowded conditions.

(2.13, B)

56. The greatest number of individuals of one kind that an environment can support with its available resources is called the:

A. carrying capacity.
B. food chain.
C. population model.
D. rate of increase.

(2.13, A)

57. The resources needed to support a population in its environment are:

A. always finite.
B. always increasing.
C. mostly abiotic.
D. usually nonfluctuating.

(2.13, A)

107

The next four items refer to the reading selection that follows. Each portion preceded by a number is an item. Read the entire selection first, then go back and key each item as follows:

(2.13, AI)

KEY: A. problem (stated or implied)
B. hypothesis (possible solution to the problem)
C. statement of observations

[58] Every 3 to 5 years, lemmings march for miles, scarcely stopping to eat or rest. Eventually they eliminate themselves by plunging into lakes, rivers, and fjords, where they drown. [59] What causes them to do this has long been a mystery. [60] In 1963, the Swedish hordes of lemmings moved south. [61] At a certain road in their path, 44 of them crossed per minute.

____ 58. (A)
____ 59. (A)
____ 60. (C)
____ 61. (C)

62. Highways are necessary for human transportation. However, they also:
    A. affect world climate.
    B. encourage animal migrations.
    C. remove land from agricultural use.
    D. stop water runoff.

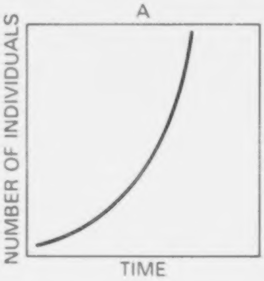
    (2.13, C)

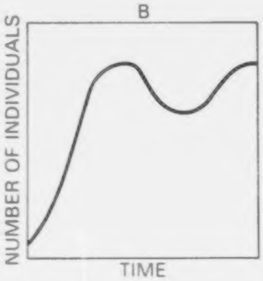
63. Scientists improve crop food yields and the resistance of crops to disease. However, with increasing land use for homes, schools, shopping centers, and industries, the gain in crop yield per hectare will be overtaken by:
    A. gain in crop yield with new pesticides.
    B. loss of hectares from crop use.
    C. lowered demand for more foods.
    D. still more new improvements to crops.

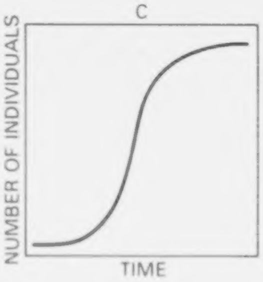
    (2.13, B)

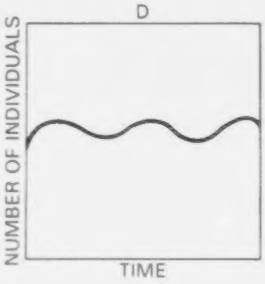
The next five items refer to the following graphs.

(2.13, AI)









____ 64. Which graph most closely resembles world human population growth for the past several centuries?

(A)

____ 65. Which graph shows a population in ecological homeostasis with the carrying capacity of its environment?

(D)

____ 66. Which graph shows the next probable stage in the curve for the world human population?

(C)

____ 67. The graph which gives no clue to the carrying capacity of the environment is:

(A)

68. If the four graphs correspond to different stages in the population curve for a single population, then their sequence would probably be:

A. A, B, C, D.
B. A, C, B, D.
C. C, B, D, A.
D. C, A, B, D.

(B)

69. The major variable in a population's density in its natural environment is likely to be:

A. available food.
B. rate of change.
C. space occupied.
D. temperature.

(2.13, A)

70. The size of each population in the earth's biosphere is limited by some factor, usually by the:

A. carrying capacities of ecosystems.
B. density of decomposer populations.
C. increase in natality over immigration.
D. seasonal times of interbreeding.

(2.13, A)

The next five items refer to causes of human mortality in the United States and the world.

(2.13, AI)

71. In the United States, improved medical treatment has resulted in a shift in this century in the major cause of death, from infectious disease to:

A. deficiency diseases and starvation.
B. degenerative diseases of aging.
C. environmental diseases.
D. home, school, or occupational accidents.

(B)

72. If other shifts in the major cause of death occur in the future in the United States, the most reasonable prediction is that the first shift would be from the present major cause to:

A. deficiency diseases and starvation.
B. degenerative diseases of aging.
C. environmental diseases.
D. home, school, or occupational accidents.

(C)

73. The reason for the prediction in the preceding item is:

A. decreased average lifespan for individuals in the U.S. and around the world.
B. decreased food supply available per individual in the world.
C. increased emphasis on home, school, and occupational safety.
D. increased industrialization and pollution in the U.S. and the world.

(D)

74. A reasonable prediction for the next major cause of death for the world human population is:

A. deficiency diseases and starvation.
B. degenerative diseases of aging.
C. environmental diseases.
D. home, school, or occupational accidents.

(A)

75. The reason for the prediction in the preceding item is:

A. decreased average lifespan for individuals in the U.S. and the world.
B. decreased food supply available per individual in the world.
C. increased emphasis on home, school, and occupational safety.
D. increased industrialization and pollution in the U.S. and the world.

(B)

Chapter 3
Communities and Ecosystems

1. A community is defined for a given place and time as a set of interacting:

   A. consumers.
   B. ecosystems.
   C. populations.
   D. producers.

   (3.1, C)

2. The biotic component of an ecosystem is a:

   A. climate.
   B. community.
   C. temperature.
   D. water.

   (3.1, B)

3. Which of the following pairs is an ecosystem?

   A. a biotic environment and a community
   B. a community and its abiotic environment
   C. a niche and a community
   D. a population and a community

   (3.1, B)

4. An abiotic environment and all the kinds of organisms that live in it make up that area's:

   A. biome.
   B. community.
   C. ecosystem.
   D. population.

   (3.1, C)

5. The difference between an ecosystem and its community of organisms is the:

   A. decomposers of the ecosystem.
   B. food web of the ecosystem.
   C. physical environment of the ecosystem.
   D. producers of the ecosystem.

   (3.1, C)

6. In biological terms a human community could more accurately be described by the term:

   A. ecosystem.
   B. habitat.
   C. niche.
   D. population.

   (3.1, AI, D)

7. All the organisms living in and on a decaying log can best be described as a:

   A. community.
   B. habitat.
   C. niche.
   D. population.

   (3.1, AI, A)

8. Which of these is a community relationship?

   A. River turtles and snails eat tape grass.
   B. Snails are concealed among rocks in a river.
   C. Tape grass clogs the water current in a river.
   D. Turtle eggs are buried on the river bank.

   (3.1, AI, A)

9. The amount of water vapor in the air, compared to the amount the air could hold at that temperature, is called:

   A. humidity index.
   B. precipitation probability.
   C. relative humidity.
   D. web-bulb temperature.

   (inv. 3.1, C)

The next seven items are based on the following feeding relationships in an ecosystem. Insects eat grasses and clover. Mice eat grass seeds and certain insects. Snakes eat insects, mice and rabbits. Rabbits eat grasses and clover. Hawks eat snakes, rabbits and mice. Wastes from mice, rabbits, insects and snakes are used by bacteria and fungi.

(3.2, AI)

10. Which organisms are producers?

    A. all of the following
    B. bacteria and mushrooms
    C. grasses
    D. mice, rabbits and deer

    (C)

11. Which organisms are decomposers?

    A. all of the following
    B. bacteria and mushrooms
    C. grasses
    D. mice, rabbits and deer

    (C)

12. What does this best represent?

    A. a food chain
    B. a food web
    C. a pyramid of numbers
    D. a pyramid of mass

    (B)

13. Which organisms can be considered consumers?

    A. all of the following
    B. bacteria and fungi
    C. grasses and clover
    D. insects, mice and rabbits

    (D)

14. Which organisms convert light energy to chemical energy via photosynthesis?

    A. all of the following
    B. bacteria and fungi
    C. grasses and clover
    D. insects, mice and rabbits

    (C)

15. Which organisms are decomposers?

    A. all of the following
    B. bacteria and fungi
    C. grasses and clover
    D. insects, mice and rabbits

    (B)

16. Which organisms lose heat energy in respiration?

    A. all of the following
    B. bacteria and fungi
    C. grasses and clover
    D. insects, mice and rabbits

    (A)

17. Inorganic compounds are converted to organic compounds by:

    A. carnivores.
    B. herbivores.
    C. omnivores.
    D. producers.

    (3.2, D)

18. Which of the following organisms is a carnivore?

    A. cat
    B. cow
    C. sheep
    D. rabbit

    (3.2, A)

19. A herbivore eats:

    A. carnivores.
    B. decomposers.
    C. omnivores.
    D. producers.

    (3.2, D)

20. A herbivore is also called a:

    A. decomposer.
    B. first-order consumer.
    C. green plant.
    D. second-order consumer.

    (3.2, B)

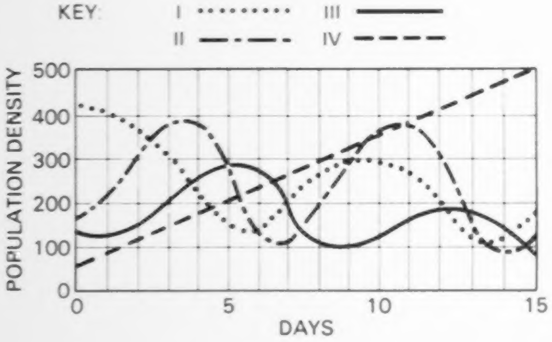
21. The place of insectivorous birds in a food chain is with:

A. carnivores.
B. herbivores.
C. parasites.
D. producers.

(3.2, A)

The next five items are based on the following graph of population data for four species of microorganisms in a community. Use the graph and its key to answer each item. Species I is a producer. The other three species are consumers.

(3.3, AI)



22. Which two species appear to depend most directly on the population level of the producers?

A. I and III
B. II and III
C. II and IV
D. III and IV

(B)

23. Which species is the most probable first-order consumer?

A. II
B. either III or IV
C. III
D. IV

(B)

24. Which species is the most probable second-order consumer?

A. II
B. either II or IV
C. III
D. IV

(C)

25. The species that shows the least relationship to living population levels for the other three species is:

A. I.
B. II.
C. III.
D. IV.

(D)

26. Which species is most likely to be a decomposer?

A. I
B. II
C. III
D. IV

(D)

---

27. The place in which an organism lives is called its:

A. community.
B. ecosystem.
C. habitat.
D. niche.

(3.3, C)

28. The difference between an organism's way of life and where it lives is described in greatest detail using the terms:

A. *animal* or *plant*, and *community*.
B. *consumer* or *producer*, and *ecosystem*.
C. *ecological niche* and *habitat*.
D. *parasite* or *free-living*, and *biome*.

(3.3, C)

Use the following interactions between organisms as responses for the next four items. Match the interactions with the terms.

(3.4, A & I)

Response	Organism I	Organism II
A	harmed	benefited
B	benefited	benefited
C	benefited	unaffected
D	harmed	unaffected

____ 29. predation:

(A)

____ 30. parasitism:

(A)

____ 31. commensalism:

(C)

____ 32. mutualism:

(B)

---

33. The relationship between an alfalfa plant and the nitrogen-fixing bacteria in nodules on its roots is one of:

A. commensalism.
B. competition.
C. mutualism.
D. parasitism.

(3.4, AI, C)

34. A bluebird that nests in an abandoned woodpecker hole illustrates a relationship between the two birds that is called:

A. commensalism.
B. competition.
C. mutualism.
D. parasitism.

(3.4, AI, A)

35. A relationship in which one organism is benefitted and the other unaffected is called:

A. commensalism.
B. competition.
C. mutualism.
D. parasitism.

(3.4, A)

36. Which of the following is an example of competition?

A. An alga makes food used by a fungus.
B. A lynx eats a wild rabbit.
C. A ramora eats bits of food that are missed by a shark.
D. A wolf eats a sheep belonging to a human.

(3.4, AI, D)

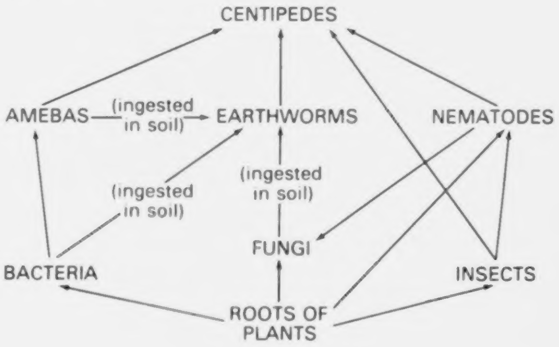
37. A house cat kills and eats a mouse. In this relationship the mouse is the:

A. host.
B. parasite.
C. predator.
D. prey.

(3.4, AI, D)

The next five items are based on this soil food web.

(3.4, AI)



38. What are the producers in this food web?

A. amoebas
B. earthworms
C. fungi
D. plants

(D)

39. Which organisms shown are the highest order consumers?

A. amoebas
B. centipedes
C. earthworms
D. nematodes

(B)

40. Which organisms are decomposers, or include many species that are decomposers?

A. amoebas, centipedes, nematodes
B. bacteria, earthworms, fungi
C. centipedes, earthworms, insects
D. insects, nematodes, plants

(B)

41. Which organisms include species that have mutualistic relationships with plant roots?

A. bacteria and fungi
B. centipedes
C. earthworms and nematodes
D. insects

(A)

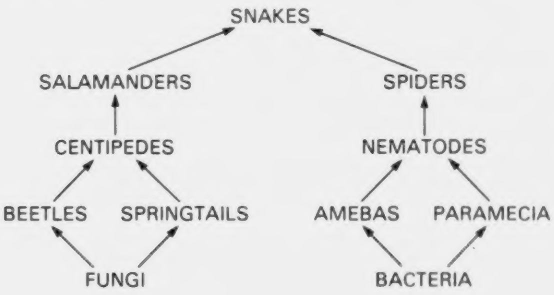
42. Which of these pairs of organisms represent a predator–prey relationship?

A. amoebas and nematodes
B. bacteria and fungi
C. centipedes and earthworms
D. insects and plants

(C)

The next four items are based on the following diagram of food relationships.

(3.4, AI)



43. The food relationships diagrammed do not include the ecosystem's:

A. consumers.
B. decomposers.
C. predators.
D. producers.

(D)

44. The beetles and springtails depend on the same fungi for food, an example of:

A. commensalism.
B. competition.
C. mutualism.
D. parasitism.

(B)

45. If the snake population declines, one result probably will be:

A. competition between spiders and salamanders.
B. decrease in centipede density.
C. emigration of the salamanders.
D. increase in nematode density.

(B)

46. The food chains in the diagram begin with:

A. decomposers.
B. herbivores.
C. predators.
D. producers.

(A)

---

47. The death of a food organism is disadvantageous to a:

A. decomposer.
B. parasite.
C. predator.
D. producer.

(3.4, B)

48. A lichen is an example of:

A. commensalism.
B. competition.
C. mutualism.
D. parasitism.

(3.4, C)

49. Two organisms that eat the same types of foods show the relationship called:

A. commensalism.
B. competition.
C. mutualism.
D. parasitism.

(3.4, B)

50. A tapeworm and the animal whose intestine the tapeworm inhabits form an association called:

A. parasite–host.
B. pathogen–host.
C. predator–prey.
D. vector–host.

(3.4, A)

51. A large herbivore such as a deer, and the microorganisms in its stomach that digest cellulose, form an association called:

A. commensalism.
B. competition.
C. mutualism.
D. parasitism.

(3.4, C)

52. The relationship between an alfalfa plant and the nitrogen-fixing bacteria in nodules on its roots is one of:

A. commensalism.
B. competition.
C. mutualism.
D. parasitism.

(3.4, C)

The next ten items refer to populations of two kinds of insects that look almost identical. Culture bottles were prepared and maintained under the conditions indicated in the following chart. Ten insects of each kind were placed together in each bottle. The insects were adequately fed. After six months, the percentage of insects of each kind present in each bottle was calculated, as below.

(3.4, AI)

		CULTURE 1	CULTURE 2	CULTURE 3	CULTURE 4	CULTURE 5	CULTURE 6
% OF INDIVIDUALS AFTER 6 MONTHS	Species X	100%	10%	75%	15%	40%	0%
	Species Y	0%	90%	25%	85%	60%	100%
CONDITIONS	Temperature °C	30°C	20°C	22°C	22°C	15°C	15°C
	Relative Humidity	80%	20%	80%	20%	80%	20%

For the first eight of the next ten items, use the following key.

KEY: A. insects of species X
B. insects of species Y
C. both kinds of insects
D. unknown from given information

____ 53. Which kind(s) of insect would you expect to find where summer temperatures exceed 40° C?

(D)

____ 54. Which kind(s) of insect is best adapted to a dry climate?

(B)

____ 55. Which kind(s) is most likely to seek shade under vegetation in warm weather?

(B)

____ 56. Which kind(s) would you expect to find active at midday in summer?

(A)

____ 57. Which kind(s) would survive freezing winters?

(D)

____ 58. Which kind(s) would survive in a hot desert?

(D)

____ 59. Which kind(s) would have the best chance of surviving in the tropics?

(A)

____ 60. Which kind(s) would you expect to find surviving at relative humidities of 40% to 60% and temperatures of 20° to 22° C?

(C)

61. Which cultures should you use as evidence for the statement, "Species X and Y probably come from different ecosystems"?

A. 1, 3, and 5
B. 1, 3, 4, and 6
C. 2, 4, and 5
D. 2, 4, 5, and 6

(B)

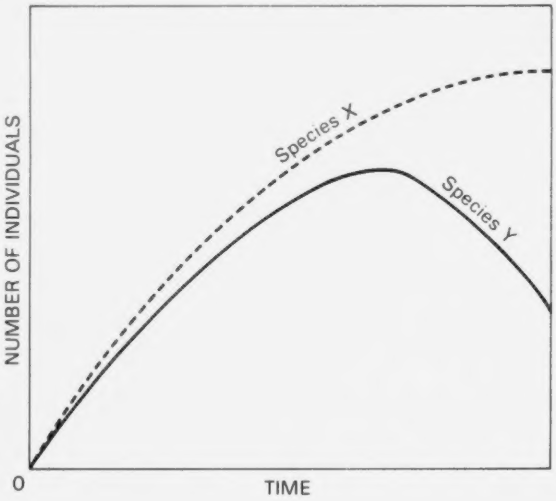
62. "Under extreme conditions, two related species that occupy the same niche may compete until one is eliminated." Which cultures give evidence for this?

A. 1 and 6
B. 2 and 4
C. 2 and 5
D. 4 and 5

(A)

The next eight items refer to the following graph of populations of two kinds of organisms in the same ecosystem. Match the keyed responses to the observations below.

(3.4, AI)



KEY: A. The graph might represent the situation described.
B. The graph could not represent the situation described.
C. The situation described is unrelated to the graphed data.

____ 63. Species X is a herbivore that feeds exclusively on Species Y, a producer:

(B)

____ 64. Species X is a predator on Species Y and other species:

(A)

____ 65. Species X and Y are competitors that use the same food until it becomes scarce, then seek other foods:

(A)

____ 66. Species Y is a parasite on Species X:

(B)

____ 67. Species X is a decomposer and Species Y, a large carnivore:

(A)

____ 68. Individuals of Species X are smaller than those of Species Y:

(C)

____ 69. Species X and Y are dependent on each other and live in a relationship of mutualism:

(B)

____ 70. Species X and Y are producers with growing seasons of different lengths of time:

(A)

For the next five items, match a letter from the key to each item.

KEY: A. commensalism
B. mutualism
C. parasitism
D. predator–prey

____ 71. a cow and the cellulose-digesting microorganisms in its stomach:

(B)

____ 72. an owl and a mouse:

(D)

____ 73. a bluebird nesting in an abandoned woodpecker hole:

(A)

____ 74. fleas on a dog:

(C)

____ 75. fungus on a plant:

(C)

---

76. Two kinds of predators that compete for food and habitats in their ecosystem are probably in the same:

A. ecological niche.
B. food chain.
C. population.
D. species.

(3.4, AI, A)

For the next ten items, identify the biological relationship in each item using the key below.

(3.4, AI)

KEY: A. commensalism
B. competition
C. mutualism
D. parasitism
E. predation

____ 77. Termites eat wood but cannot digest it. Microorganisms that live in the termites' digestive tracts digest the wood. The microorganisms cannot live outside the termites' bodies:

(C)

____ 78. A gopher goes on its way as two animals that *were* after it, a coyote and a snake, encounter one another instead. The coyote and the snake back each other off in a standoff:

(B)

____ 79. A cricket may live in a gopher burrow along with the gopher. Each animal is harmless to the other unless the gopher accidentally steps on the cricket:

(A)

____ 80. A lamprey eel attaches itself by a sucker to a fish and feeds on blood from the fish:

(D)

____ 81. An eagle sees a young rabbit and dives on it from aloft:

(E)

____ 82. Tapeworms live in animal intestines and grow new segments as they absorb digested foods. An animal may become undernourished as tapeworm segments are lost with eliminated wastes and the tapeworms grow more new segments:

(D)

____ 83. Old historical documents report overweight human beings who deliberately ingested tapeworms. A relatively simple medication would keep the tapeworms in check:

(C)

____ 84. A starfish attaches its tube feet to an oyster's shell and pulls until the oyster's fatigued muscles can no longer hold the shell closed:

(E)

____ 85. Garden seeds that sprout only inches apart cause the plants to be crowded and their growth and fruiting reduced:

(B)

---

86. What is the relationship between ecosystems?

A. Their abiotic factors are distinct, but their biotic factors are interconnected.
B. Their biotic factors are distinct, but their abiotic factors are interconnected.
C. Their boundaries are distinct.
D. They are interconnected to form the biosphere.

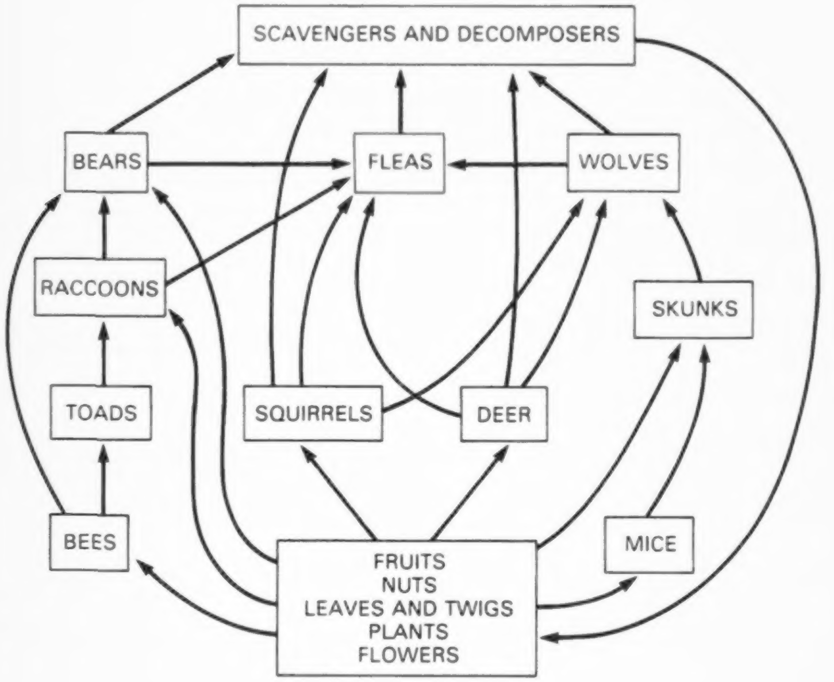
(3.5, D)

87. The abiotic factor that most affects terrestrial organisms and where they live is:

A. climate.
B. geographic range.
C. soil type.
D. succession.

(3.6, A)

The next five items are based on the following diagram of a food web in North America.
(3.4–3.7, AI)


SCAVENGERS AND DECOMPOSERS
BEARS
FLEAS
WOLVES
RACCOONS
SKUNKS
TOADS
SQUIRRELS
DEER
BEES
MICE
FRUITS
NUTS
LEAVES AND TWIGS
PLANTS
FLOWERS

88. Three omnivores in this food web are:
    - A. bears, raccoons, and skunks.
    - B. fleas, scavengers, and decomposers.
    - C. mice, raccoons, and skunks.
    - D. squirrels, toads, and wolves.

    (A)

89. Productivity in the food web is measured at the level of the:
    - A. carnivores.
    - B. herbivores.
    - C. plants.
    - D. scavengers and decomposers.

    (C)

90. The greatest amount of food energy in this food web is consumed by the:
    - A. bear population.
    - B. deer and squirrel populations.
    - C. plant populations.
    - D. wolf population.

    (C)

91. The recycling of materials in the food web is completed by the:
    - A. carnivores
    - B. herbivores.
    - C. plants.
    - D. scavengers and decomposers.

    (D)

92. The carnivores and insectivores in this food web are the:
    - A. bears, fleas, and wolves.
    - B. fleas and wolves.
    - C. squirrels, skunks, and wolves.
    - D. wolves and toads.

    (D)

93. A pyramid of biomass means that the mass of:

A. consumers is greater than producers.
B. decomposers is greater than consumers.
C. decomposers is greater than producers.
D. producers is greater than consumers.

(3.7, D)

94. Which is usually most numerous in a terrestrial community?

A. consumers #1
B. consumers #2
C. decomposers
D. producers

(3.7, D)

95. Which is most important in limiting the size of a community? The:

A. amount of energy entering it
B. biomass of decomposers
C. number of consumers
D. size of producers

(3.7, A)

96. Which of the following kinds of organisms would an ecologist predict to be most numerous in an ecosystem?

A. carnivores
B. herbivores
C. omnivores
D. producers

(3.7, D)

97. Gross primary productivity in an ecosystem is the:

A. energy lost by the daily activity of producers in the community.
B. food energy available to consumers.
C. growth of the community.
D. sunlight energy converted by producers to chemical energy.

(3.7, D)

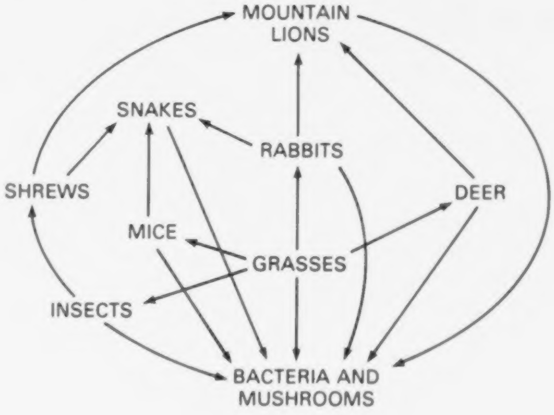
98. Net productivity in an ecosystem is defined as:

A. energy lost by the daily activity of producers in the community.
B. food energy available to consumers.
C. growth of the community.
D. light energy converted by producers to chemical energy.

(3.7, B)

The next seven items are based on the following diagram of a food web in a land environment.

(3.7, AI)



99. Which organisms supply energy for all the others?

A. bacteria and mushrooms
B. grasses
C. mice and insects
D. rabbits

(B)

100. In terms of numbers of individuals, you would expect to find more:

A. deer than mountain lions.
B. mice than insects.
C. mountain lions than shrews.
D. shrews than rabbits.

(A)

101. Which group of organisms would have the greatest total mass or weight?

A. bacteria
B. deer
C. grasses
D. mountain lions

(C)

102. Most of the groups of organisms shown are:

A. carnivores.
B. consumers.
C. omnivores.
D. producers.

(B)

103. If mountain lions increased in numbers, a count of rabbits and deer would probably reveal that they had:

A. bred less frequently.
B. escaped detection.
C. decreased in numbers.
D. increased in numbers.

(D)

104. Which organisms are producers?

A. all of the following
B. bacteria and mushrooms
C. grasses
D. mice, rabbits and deer

(C)

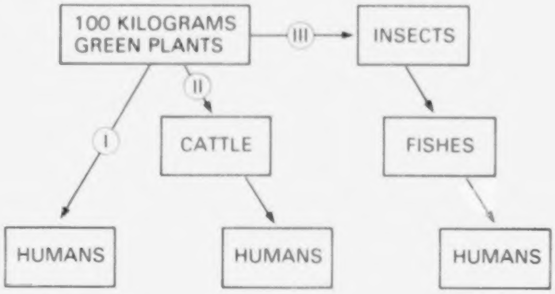
105. Which organisms are decomposers?

A. all of the following
B. bacteria and mushrooms
C. grasses
D. mice, rabbits and deer

(C)

The next four items refer to the following diagram. The arrows indicate three possible pathways the energy produced by the green plants could take.

(3.7, AI)



106. Through which pathway would the most energy be available to humans?

A. I
B. II
C. II or III
D. III

(A)

107. Through which pathway would the least energy be available to humans?

A. I
B. I or II
C. II
D. III

(D)

108. In which pathway does the most energy escape as heat?

A. I
B. I or II
C. II
D. III

(D)

109. Which pathway will be favored more if the world human population doubles in size?

A. I
B. II
C. II or III
D. III

(A)

110. The stability of a community generally increases with a:

A. greater diversity of organisms and more links in the food web.
B. greater number of organisms and fewer links in the food web.
C. lower diversity of organisms and fewer links in the food web.
D. smaller number of organisms and more links in the food web.

(3.8, A)

111. Which best describes the relationship between the number of different kinds of organisms in an ecosystem and the ecosystem's stability?

A. There is no relationship.
B. The larger the number the greater the stability.
C. The smaller the number the greater the stability.
D. Too small *or* too large a number the lower the stability.

(3.8, AI, B)

112. How has our use of the insecticide DDT affected ecosystems? DDT has:

A. accumulated in predators, killing them and resulting in ecosystem instability.
B. accumulated in predators, killing them and resulting in ecosystem stability.
C. killed insects, resulting in a more complex and stable ecosystem.
D. killed insects, resulting in a simpler and more stable ecosystem.

(3.9, A)

113. Which is a biocide?

A. all of the following
B. fungicides
C. herbicides
D. insecticides

(3.9, A)

114. Which is *not* involved in the concentration of DDT in a food chain?

A. DDT is not easily broken down by consumers.
B. DDT is not stored in consumers.
C. Producer bodies are broken down and used by consumers.
D. A consumer eats many producers.

(3.9, AI, B)

115. As the human population has grown, the effect of changes made by people in the ecosystems surrounding them has been to:

A. add to the number of species.
B. improve the climate.
C. leave the maximum number of ecosystems undisturbed.
D. simplify the ecosystems.

(3.9, AI, D)

116. Which explains how human activity can create biocide-resistant organisms?

A. all of the following
B. Biocide resistance is inherited from generation to generation.
C. Most of the pests are killed by the spray.
D. Surviving pests reproduce large numbers of offspring.

(3.10, AI, A)

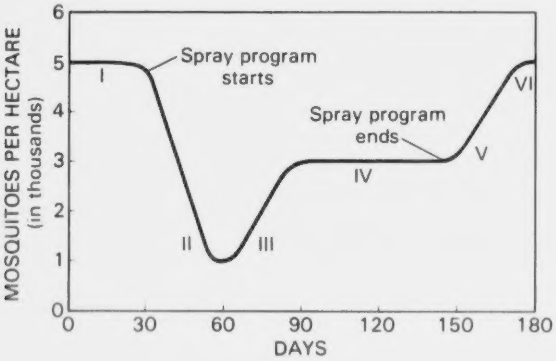
117. Human intervention in ecosystems usually has the result of:

A. decreasing the number of species.
B. increasing the productivity for most consumers.
C. increasing the stability of the ecosystems.
D. modifying the ecological niches for decomposers.

(3.10, AI, A)

The next seven items refer to a tropical island heavily infested with malarial mosquitoes. The island was sprayed with DDT for a period of several months during the summer. Daily counts of mosquito samples and estimates of total population size gave the information shown in the graph.

(3.9–3.10, AI)



118. What was learned from the spray program?
    - A. Malaria can be controlled by DDT.
    - B. Mosquitoes can be eliminated with DDT.
    - C. Mosquitoes immigrate from other islands to replace those killed.
    - D. Spraying became less effective within 90 days.

    (D)

119. The change that began at III in the graph was probably due to:
    - A. immigration of mosquitoes from other islands.
    - B. normal reproduction time for the mosquitoes.
    - C. onset of greatest summer heat.
    - D. reproduction of DDT-resistant mosquitoes.

    (D)

120. What hypothesis would you offer about the mosquito population at VI in the graph?
    - A. DDT will affect them less than the original population.
    - B. DDT will affect them about the same as the original population.
    - C. DDT will affect them more than the original population.
    - D. DDT will not affect them at all.

    (A)

121. The population change in the mosquitoes probably occurred because of natural selection and was first noticed in the graph at:
    - A. I
    - B. III.
    - C. V.
    - D. VI.

    (B)

122. The differences in the gene pool of the mosquitoes was probably greatest at points:
    - A. I and II.
    - B. I and III.
    - C. III and IV.
    - D. IV and VI.

    (B)

123. Some mosquitoes on the island can still be killed by DDT. This is probably because of:
    - A. immigration from areas where DDT was not used.
    - B. protected areas on the island where the DDT did not penetrate.
    - C. recombinations of genes in sexual reproduction of the survivors.
    - D. stronger dosages of DDT in new test applications.

    (C)

124. A number of different insecticides do not kill insects as effectively as they once did. This is probably because the:

A. environment is changing.
B. insecticides are from a different manufacturing lot.
C. susceptible insects have been eliminated.
D. world climate is growing warmer.

(C)

---

125. Which is *not* true about extinction?

A. all of the following
B. It can be caused by habitat destruction.
C. It is an unnatural process.
D. Species of organisms are lost forever.

(3.11, C)

126. Why is rapid human-caused extinction of organisms bad?

A. all of the following
B. It may reduce the stability of ecosystems.
C. Their medical potential may not be realized.
D. They cannot contribute genetic variability to crops.

(3.11, AI, A)

127. Which is the best reason to preserve wilderness areas? So we can:

A. cut timber in them
B. have undisturbed areas to hike and camp in
C. hunt and fish in them
D. study natural communities

(3.12, D)

Chapter 4
Matter and Energy in the Web of Life

1. What determines the way atoms react? The:

   A. number of atoms present.
   B. number of electrons in the atoms.
   C. size of molecules.
   D. size of the protons.

   (4.1, B)

For the next three questions, use the following terms as responses. Any term may be used more than once or not at all.

(4.1)

KEY: A. atoms
B. compounds
C. elements
D. protons

____ 2. the smallest and most basic particles of matter:

(A)

____ 3. the simplest substances into which matter can be broken:

(C)

____ 4. held together by chemical bonds:

(B)

---

5. Which would have the higher pH?

   A. lemons
   B. shrimp
   C. tomatoes
   D. vinegar

   (inv. 4.1, AI, B)

6. The following pH measurements were obtained:
   distilled water = 6.0
   fresh water (lake) = 6.8
   blood plasma (human) = 7.5
   sea water = 8.2

   Which was the most acid?

   A. blood plasma
   B. distilled water
   C. fresh water
   D. sea water

   (4.1, AI, B)

7. When atoms of different elements share or exchange some of the particles of which they are made, they form:

   A. compounds.
   B. cycles.
   C. foods.
   D. mixtures.

   (4.1, A)

8. How do atoms of carbon and oxygen differ?

   A. all of the following
   B. the number of electrons
   C. the number of neutrons
   D. the number of protons

   (4.1, A)

9. What must happen in order for substances to chemically react? They must:

   A. come in contact with each other.
   B. have the same number of electrons.
   C. have the same number of atoms.
   D. neutralize each other.

   (4.2, A)

10. Acids give off more:

A. hydrogen ions and have a low pH.
B. hydrogen ions and have a high pH.
C. hydroxide ions and have a low pH.
D. hydroxide ions and have a high pH.

(4.2, A)

11. Which pair of terms means approximately the same as synthesis and decomposition?

A. energizing and de-energizing
B. organizing and disorganizing
C. putting together and taking apart
D. speeding up and slowing down

(4.2, C)

12. Which is *not* true of enzymes? They:

A. are large, complex proteins.
B. are needed only in small amounts.
C. break down during the reaction.
D. combine with substrates in their active sites.

(4.2, C)

13. Living things differ from nonliving things in using energy to:

A. avoid change in natural order.
B. maintain an organized condition.
C. reach a random state.
D. simplify randomness.

(4.3, B)

14. In the absence of an outside energy source, living materials tend to become:

A. disorganized.
B. energy-independent.
C. energy producers.
D. more organized.

(4.3, A)

15. In what form do producers store the energy that is obtained from sunlight?

A. body heat
B. chemical energy
C. mechanical energy
D. nuclear energy

(4.4, B)

16. Inorganic compounds are converted to organic compounds by:

A. carnivores.
B. herbivores.
C. omnivores.
D. producers.

(4.4, D)

17. Converting available energy into a form useful to all organisms is accomplished on Earth through:

A. fermentation.
B. photosynthesis.
C. protein synthesis.
D. respiration.

(4.4, B)

18. The oxygen on which organisms depend for cellular respiration is supplied to the atmosphere by:

A. fermentation.
B. ozone breakdown.
C. photosynthesis.
D. protein synthesis.

(4.4, C)

19. A biologist would expect an organism to be a producer if it contained:

A. cells.
B. chlorophyll.
C. energy.
D. organic compounds.

(4.4, B)

20. In the laboratory, heat energy accelerates chemical reactions. In nature, organisms would be damaged by high heat. All organisms accelerate chemical reactions at lower temperatures using:

A. enzymes.
B. hormones.
C. stimulants.
D. substrates.

(4.5, A)

21. Any substance whose presence speeds up a chemical reaction between other substances is called a:

A. calorie.
B. catalyst.
C. synthesist.
D. substrate.

(4.5, B)

22. Why is ATP important as an energy-transfer compound?

A. ATP is a large molecule with a large amount of energy.
B. ATP is a small molecule with a small amount of energy.
C. Energy is released when ATP's third phosphate is removed.
D. Phosphates from ATP are used in all organic compounds.

(4.6, C)

23. Which is the most important energy-transfer compound in organisms?

A. amino acid
B. ATP
C. fat
D. glucose

(4.6, B)

24. Energy is most quickly available for all animal activities when it is in the form of:

A. ADP.
B. ATP.
C. blood glucose.
D. DNA.

(4.6, B)

Use the following kinds of organic compounds to identify items 25 through 28. Match the description or function with the kind of compound.

(4.7)

KEY: A. carbohydrates
B. lipids
C. nucleic acids
D. proteins

____ 25. enzymes:
(D)

____ 26. hereditary material:
(C)

____ 27. produced directly in photosynthesis:
(A)

____ 28. muscles are composed largely of:
(D)

---

29. How are sugar molecules made in photosynthesis used by plants?

A. all of the following
B. to provide building blocks for growth
C. to provide energy when broken down in respiration
D. to store energy for long-term use

(4.8, A)

30. Which type of compound is used as a building material for plant cell walls?

A. cellulose
B. lipids
C. proteins
D. starch

(4.8, A)

31. Which type of compound is used as a storage material in plant cells?

A. cellulose
B. lipids
C. proteins
D. starch

(4.8, D)

32. In the carbon cycle, carbon dioxide is taken from the atmosphere and used by:

A. first-order consumers.
B. decomposers.
C. producers.
D. second-order consumers.

(4.9, C)

33. In the carbon cycle, carbon dioxide is released to the atmosphere by:
    A. all organisms.
    B. consumers only.
    C. consumers and decomposers only.
    D. producers and decomposers only.

(4.9, A)

34. Which organisms are essential to the carbon cycle?
    A. consumers and decomposers
    B. first- and second-order consumers
    C. producers and consumers
    D. producers and decomposers

(4.9, D)

35. Sugars, starches, cellulose, and other similar organic compounds which contain only carbon, hydrogen, and oxygen are called:
    A. amino acids.
    B. carbohydrates.
    C. nucleic acids.
    D. proteins.

(4.10, B)

36. Sucrose, or table sugar, differs from glucose and fructose in being a:
    A. carbohydrate.
    B. catalyst.
    C. disaccharide.
    D. polypeptide.

(4.10, B)

37. The basic unit of a polysaccharide is a molecule of a simple:
    A. alcohol.
    B. amino acid.
    C. nucleic acid.
    D. sugar.

(4.10, D)

38. Fats, oils, and waxes are all:
    A. carbohydrates.
    B. lipids.
    C. nucleotides.
    D. proteins.

(4.11, B)

39. Fats are synthesized from fatty acids and:
    A. alcohol.
    B. carotene.
    C. catalysts.
    D. glycerol.

(4.11, D)

40. Most enzymes are:
    A. carbohydrates.
    B. lipids.
    C. nucleic acids.
    D. proteins.

(4.11, D)

41. The largest molecules synthesized by organisms are those of:
    A. carbohydrates.
    B. fats and oils.
    C. nucleic acids.
    D. proteins.

(4.11, C)

42. Fats are important energy storage compounds because they:
    A. are converted to cholesterol.
    B. break down easily.
    C. contain more chemical energy per gram than carbohydrates or proteins.
    D. form complex compounds in body tissues.

(4.11, C)

43. Fats, like sugars and starches, contain only carbon, hydrogen, and oxygen. However, they contain more food energy than sugars and starches because of their greater number of:

A. carbon atoms.
B. chemical bonds.
C. hydrogen atoms.
D. oxygen atoms.

(4.11, C)

44. Approximately how many different amino acids are found in human proteins?

A. 5
B. 10
C. 15
D. 20

(4.12, D)

45. Proteins are synthesized from amino acids in long chains called:

A. carbon chains.
B. polypeptides.
C. polysaccharides.
D. ribonucleic acids.

(4.12, B)

46. Unlike animals, plants can synthesize their own:

A. amino acids.
B. DNA.
C. enzymes.
D. proteins.

(4.12, A)

47. All proteins contain carbon, hydrogen, oxygen, and:

A. calcium.
B. iron.
C. nitrogen.
D. potassium.

(4.12, C)

48. Which is characteristic of enzymes?

A. all of the following
B. They are not used up in the reactions.
C. They combine with substrates.
D. They speed up the rates of reactions.

(4.13, A)

49. Most of a cell's enzymes have the chemical structure of:

A. carbohydrates.
B. lipids.
C. nucleic acids.
D. proteins.

(4.13, D)

50. In living cells, enzymes do not as a rule:

A. affect particular substrates.
B. react with the substrates.
C. remain permanently linked to the substrates.
D. survive their reaction with the substrates.

(4.13, C)

51. Any substance whose presence speeds up a chemical reaction between other substances is called a:

A. calorie.
B. catalyst.
C. synthesist.
D. substrate.

(4.13, B)

The next four items are based on an experiment in which five drops of methyl red and a brass screw were added to each of four test tubes. Organisms X and Y were then placed in the tubes as indicated in the table, and the tubes were sealed. The brass screws kept the organisms out of the methyl red.

(inv. 4.3, AI)

Methyl red is an indicator that changes from yellow to red in the presence of carbon dioxide.

Tube	Organism	Conditions	Color of indicator
I	X	Dark	Red
II	X	Light	Red
III	Y	Dark	Red
IV	Y	Light	Yellow

52. In which tube was the carbon dioxide used?
    - A. I
    - B. II
    - C. III
    - D. IV

    (D)

53. What are the probable natures of the organisms in terms of how they would fit into a food chain?
    - A. X is a producer, Y a consumer.
    - B. X and Y are both consumers.
    - C. X and Y are both producers.
    - D. Y is a producer, X a consumer.

    (D)

54. In which sealed tubes should you expect the organisms' lives to be endangered first?
    - A. I, II, and III
    - B. I, II, and IV
    - C. I, III, and IV
    - D. II, III, and IV

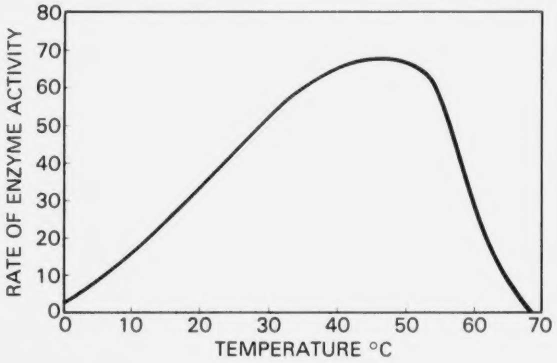
    (A)

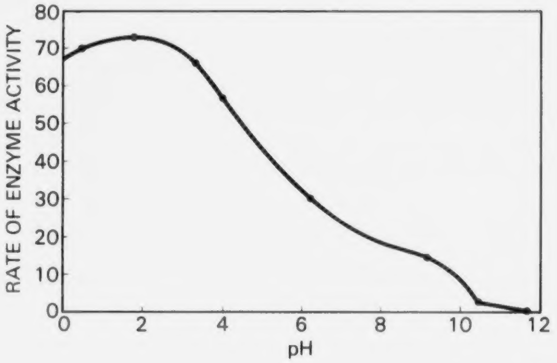
55. A useful control for this experiment would be a fifth sealed tube containing only air and:
    - A. a brass screw.
    - B. five drops of methyl red.
    - C. organism X.
    - D. organism Y.

    (B)

The next five items refer to the following information and graphs. Both graphs refer to the same enzyme. The first graph shows the enzyme's rate of activity at different temperatures. The second graph shows the enzyme's rate of activity at different pH values. A pH below 7 is acid; above 7, basic.

(inv. 4.3, AI)





56. This enzyme is most active at a temperature of:
    - A. 10° to 20° C.
    - B. 20° to 30° C.
    - C. 30° to 40° C.
    - D. 40° to 50° C.

    (D)

57. The data indicate that a temperature above 53° or 54° C may supply enough energy in the form of heat to:

A. assist the enzyme's reactions.
B. damage or destroy the enzyme.
C. make fewer enzyme molecules needed.
D. replace the energy supplied by the enzyme.

(B)

58. Enzymes are normally active at a wider temperature range than the average temperature of the organism in which they are found. This is especially important for:

A. terrestrial organisms that do not internally regulate their body temperature.
B. deep-water marine organisms.
C. seasonally migrating terrestrial organisms.
D. marine organisms that maintain constant body temperature.

(A)

59. The data indicate that this enzyme is most active at a pH of:

A. 1.
B. 2.
C. 4.
D. 6.

(B)

60. A human organ in which the pH is acid, and at times is very acid, is the stomach. The actual pH varies according to how much gastric juice dilutes the stomach's secretion of hydrochloric acid. Which of the following statements best summarizes whether the enzyme represented by the graphed data could be a human enzyme?

A. It could be a human digestive enzyme that hydrolizes proteins in the stomach.
B. It could be a human enzyme that synthesizes new cell proteins in the stomach
C. It could not be a human enzyme, because average human body temperature is about 37° C.
D. It could not be a human enzyme, because it is inactive in diluted acid.

(A)

61. Nucleic acids are made up of:

A. amino acids.
B. fatty acids.
C. nucleotides.
D. polypeptides.

(4.14, C)

62. What is the main function of DNA? To:

A. act as enzymes
B. act as messages used in protein synthesis
C. store energy for the cell functions
D. store the genetic information

(4.14, D)

63. How do RNA and DNA differ?

A. all of the following
B. DNA is double-stranded, RNA is single-stranded.
C. DNA is made up of nucleotides, RNA is not.
D. DNA sugar has 5 carbon atoms, RNA sugar has 6 carbon atoms.

(4.14, B)

64. What is a nucleotide?

A. all of the following
B. a nitrogen base, a phosphate and a 5-carbon sugar linked together
C. the basic subunit of proteins
D. the genetic code unit (codon)

(4.14, B)

65. Everything the organisms of an ecosystem use is recycled except:

A. air.
B. energy.
C. food wastes.
D. water.

(4.14, B)

66. Ribose in RNA, and deoxyribose in DNA, are both:

A. amino acids.
B. five-carbon sugars.
C. nucleic acids.
D. six-carbon sugars.

(4.14, B)

Chapter 5
Continuity in Cells

1. Robert Hooke first used the word *cell*, in its meaning of "small room," for microscopic:

   A. boxlike mitochondria.
   B. compartments in cork.
   C. hollows in seashells.
   D. spaces within vacuoles.

   (5.1, B)

2. Later it was discovered that in living material these cells were filled with:

   A. air.
   B. complex liquid.
   C. dried particles.
   D. membranes.

   (5.1, B)

3. What was Antony van Leeuwenhoek's contribution to biology?

   A. He first proposed the cell theory.
   B. He invented the compound microscope.
   C. Using his compound microscope he looked at sections of cork and described and named cells.
   D. Using simple but excellent microscopes, he described bacteria, sperm, and small creatures.

   (5.1, D)

4. As the cell theory became established, it included each of the following ideas *except* that:

   A. all cells have the same internal parts.
   B. all cells come from pre-existing cells.
   C. cells are the units of function in organisms.
   D. cells are the units of structure in organisms.

   (5.1, A)

5. According to the cell theory, microscopic examination of a body tissue from a previously undiscovered organism will reveal:

   A. acellular structures with nuclei.
   B. clearly defined cells.
   C. either cells or structures made by cells.
   D. meiosis occurring in the cells.

   (5.1, C)

6. Which advance in microscopy directly led to the discovery of organelles? The:

   A. invention of the electron microscope
   B. invention of the time-lapse camera
   C. use of stains
   D. use of the single-lens microscope

   (5.2, C)

The next nine items refer to the relationship between biological tools and the discoveries made with them. Assume that the tools named in the key are listed in the order in which they came into use. For each discovery stated in an item, select the *earliest* tool that made the discovery possible.

(5.2–5.4, AI)

KEY: A. compound microscope
B. biological dyes
C. chemical analysis
D. electron microscope

____ 7. The nucleus contains threadlike structures called chromosomes:

(B)

____ 8. The outer boundary of the cytoplasm is a definite structure:

(A)

____ 9. Within each cell is a prominent spherical structure, the nucleus:

(A)

132

____ 10. The endoplasmic reticulum forms a network of channels in the cytoplasm:

(D)

____ 11. The channels of the endoplasmic reticulum are covered with spherical structures called ribosomes:

(D)

____ 12. The cell membrane is composed of both proteins and fats:

(C)

____ 13. Chromatids are formed during mitosis:

(B)

____ 14. The nucleolus is a small oval body within the nucleus:

(B)

____ 15. Cell parts, such as ribosomes have internal structure:

(D)

---

16. Some cell structures could not be detected until electron microscopes were invented. An example is:

    A. chloroplasts.
    B. mitochondria.
    C. nuclei.
    D. ribosomes.

    (5.3, D)

17. Animal and plant cells share:

    A. all of the same organelles.
    B. few of the same organelles.
    C. most of the same organelles.
    D. none of the same organelles.

    (5.5, C)

18. Cells that carry on intracellular digestion do not digest themselves partly because they secrete their digestive enzymes into membrane-enclosed:

    A. centrosomes.
    B. chromosomes.
    C. lysosomes.
    D. ribosomes.

    (5.5, C)

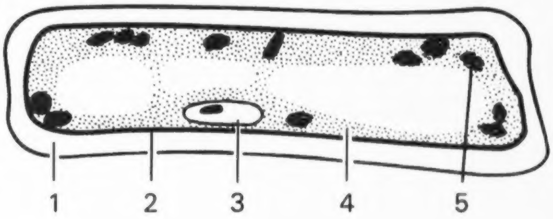
19. Cellular respiration is carried on by:

    A. chromosomes.
    B. centrosomes.
    C. mitochondria.
    D. ribosomes.

    (5.5, C)

The next six items are based on the following diagram of a cell as seen using a microscope.

(5.5, AI)



20. Which cell part contains the chromosomes?

    A. 1
    B. 2
    C. 3
    D. 4

    (C)

21. Which cell part controls the movement of substances into and out of the cell?

    A. 1
    B. 2
    C. 4
    D. 5

    (B)

22. Which numbered parts are not found in animal cells?

A. 1 and 2
B. 1 and 3
C. 1 and 4
D. 1 and 5

(D)

23. Which cell part is the cytoplasm?

A. 2
B. 3
C. 4
D. 5

(C)

24. Which cell part is constructed of nonliving material?

A. 1
B. 2
C. 3
D. 4

(A)

25. Which cell part is composed primarily of lipids?

A. 1
B. 2
C. 3
D. 4

(B)

The next three items refer to the following information and table.

(5.5, AI)

Cells were cut so that one half of the cell fragment contained a nucleus and the other half did not. The fragments with nuclei were separated from those without nuclei. From each group, 100 fragments were placed in containers of nutrient medium under uniform conditions. The table indicates the results.

	Nonnucleated fragments	**Nucleated fragments**
Initial sample	100	100
Surviving 1 day	80	79
Surviving 2 days	60	74
Surviving 3 days	30	72
Surviving 4 days	3	72

26. The data indicate that for this type of cell:

A. a nucleated cell half usually can repair itself.
B. a nucleus is not involved in repair of injury.
C. a ruptured cell membrane is fatal.
D. a whole cell whose nucleus stops functioning would die in 3 to 5 days.

(A)

27. The conclusion indicated by the data would be strengthened by the:

A. death of the three remaining fragments without nuclei.
B. observation of whole cells with their nuclei removed.
C. removal of the nuclei from the 72 nucleated survivors.
D. resumption of normal cell activities by the 72 nucleated survivors.

(D)

28. Which of the following assumptions was made in this experiment?

A. All cells were about to undergo mitosis when cut in two.
B. Equal numbers of fragments of each kind would survive.
C. A normal cell's lifespan is four days.
D. The same cytoplasmic materials were present in all fragments.

(D)

For the next four questions, match the following organelles with their descriptions and/or functions.

(5.5)

KEY: A. cell walls
B. chromosomes
C. microtubules
D. ribosomes

____ 29. contain the genes; are visible only during division:

(B)

____ 30. tiny bodies where proteins are synthesized:

(D)

____ 31. found only in plants; give plants rigidity:

(A)

____ 32. composed of proteins; organized in network that forms the cell skeleton:

(C)

---

33. Investigations of animal, plant, and protist cells have revealed that all cells have:

A. cell membranes.
B. centrosomes.
C. organized nuclei.
D. plastids.

(5.5, A)

34. Dark-staining small spherical bodies within a cell nucleus are called:

A. chromosomes.
B. nucleoli.
C. plastids.
D. vacuoles.

(5.5, B)

35. Dark-staining threadlike bodies within a cell nucleus are called:

A. chromosomes.
B. mitochondria.
C. nucleoli.
D. plastids.

(5.5, A)

36. Membrane-enclosed bags in the cytosol which contain food or fluid are known as:

A. chloroplasts.
B. nucleoli.
C. plastids.
D. vacuoles.

(5.5, D)

Use the following organelles as responses for the next four items. Match the descriptions or functions with the organelles.

(5.5)

KEY: A. endoplasmic reticulum
B. Golgi complex
C. lysosome
D. mitochondrion

____ 37. powerhouse of the cell; releases energy from nutrients by respiration:

(D)

____ 38. network of tubules; transports materials within the cell:

(A)

____ 39. vesicle containing digestive enzymes:

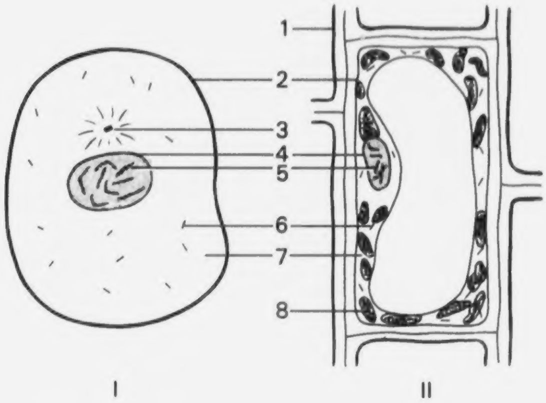
(C)

____ 40. sac-like structures that package materials in vesicles:

(B)

The next eight items are based on the following drawings of cells. Match a number from the drawings to each item.

(5.5)



____ 41. nucleus:

(4)

____ 42. cell wall:

(1)

____ 43. cell membrane:

(2)

____ 44. centrosome:

(3)

____ 45. chloroplast:

(8)

____ 46. mitochondria:

(6)

____ 47. cytosol:

(7)

____ 48. chromosomes:

(5)

49. Ribosomes are the sites of a cell's:

A. air exchange.
B. digestion.
C. energy powerhouses.
D. protein synthesis.

(5.5, D)

50. Before energy can be released from foodstuffs, digestion of large food molecules occurs with the aid of:

A. centrosomes.
B. chromosomes.
C. lysosomes.
D. ribosomes.

(5.5, C)

51. Cell secretions are packaged by the:

A. endoplasmic reticulum.
B. Golgi complex.
C. mitochondria.
D. nucleus.

(5.5, B)

52. The control center of a cell is the:

A. cell membrane.
B. cytoplasm.
C. endoplasmic reticulum.
D. nucleus.

(5.5, D)

53. The more active a cell or tissue such as muscle, the greater the number of which of the following structures it contains?

A. chromosomes
B. mitochondria
C. nuclei
D. lysosomes

(5.5, B)

54. Numerous channels within the cytoplasm of a cell appear to be formed by a membranous network called the:

A. endoplasmic reticulum.
B. Golgi apparatus.
C. mitochondria.
D. nuclear membrane.

(5.5, A)

55. Which of the following types of cell structures in plant cells and in many protists carries on photosynthesis?

A. lysosomes
B. chloroplasts
C. mitochondria
D. ribosomes

(5.5, B)

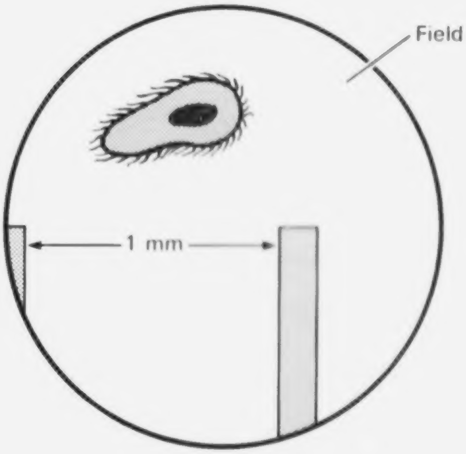
56. Which of the following types of structures in animal, plant, and many protist cells releases energy from foods and makes it available for cell activities?

A. chloroplasts
B. lysosomes
C. mitochondria
D. ribosomes

(5.5, C)

The next four items refer to the following field of view as seen through a compound microscope.

(inv. 5.1, AI)



57. To keep the moving organism in view as it swims across the field of view to the right, the slide under the microscope should be moved to the:

A. front.
B. left.
C. rear.
D. right.

(D)

58. What is the actual direction of the organism's movement on the slide in relation to the direction in which it is seen moving through the microscope?

A. 90° clockwise
B. 90° counterclockwise
C. opposite
D. same

(C)

59. The length of the organism is approximately:

A. 0.05 mm.
B. 0.5 mm.
C. 1.0 mm.
D. 1.5 mm.

(B)

60. The approximate diameter of the field of view in micrometers (μm) is:

A. 500.
B. 1000.
C. 1500.
D. 2000.

(C)

Four microscopes are set up in the laboratory as follows:

(inv. 5.1, AI)

Microscope number	Objective	Ocular
1	10X	5X
2	20X	10X
3	40X	5X
4	40X	10X

61. A moving organism on a slide will appear to move at the same rate of speed under either of the two microscopes numbered:

A. 1 and 2.
B. 1 and 3.
C. 2 and 3.
D. 2 and 4.

(C)

62. Under which microscope could you expect to see the most organisms in a single field of view?

A. 1
B. 2
C. 3
D. 4

(A)

63. Which microscope has a field of view that is smallest in diameter?

A. 1
B. 2
C. 3
D. 4

(D)

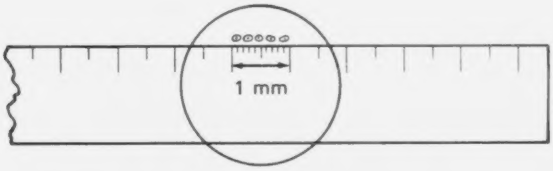
64. The chief advantage of higher magnification is to:

A. get better focus.
B. see smaller objects.
C. see a wider field.
D. slow down movement.

(B)

A clear plastic ruler is placed alongside a row of objects on a slide and viewed with the objects through a microscope. The field of view is shown by the circle.

(inv. 5.1, AI)



65. To measure the lengths of the objects, you should:

A. divide their apparent lengths by the magnification.
B. multiply their apparent lengths by the magnification.
C. read the ruler's divisions directly.
D. read the ruler's divisions and multiply by two.

(C)

66. The average length of these objects in micrometers (μm) is approximately:

A. 1.
B. 100.
C. 200.
D. 2000.

(C)

---

67. The study of the functions of cells, tissues, organs, and organisms is called:

A. anatomy.
B. differentiation.
C. metabolism.
D. physiology.

(5.6, D)

68. Part of a cell's exchange of materials with its environment is done by a physical process rather than a biological one. The name of this process is:

A. active transport.
B. diffusion.
C. photosynthesis.
D. secretion.

(5.7, B)

69. Some but not other materials are admitted through a cell membrane, not always according to their size. A membrane of this nature is said to be:

A. actively permeable.
B. differentially permeable.
C. non-permeable.
D. porous.

(5.7, B)

70. A cell does not need to use energy in:

A. active transport.
B. diffusion.
C. metabolism.
D. mitosis.

(5.7, B)

71. When a cell concentrates materials inside or outside its cell membrane, it is using energy in:

A. active transport.
B. metabolism.
C. osmosis.
D. passive or simple diffusion.

(5.7, A)

72. In diffusion, random motion of molecules tends to move the molecules from where they are:

A. concentrated to where they are needed.
B. less concentrated to where they are more concentrated.
C. more concentrated to where they are less concentrated.
D. used to where they are eliminated as wastes.

(5.7, C)

73. In diffusion, molecules tend to move:

A. from areas of high concentration to areas of lower concentration.
B. from areas of low concentration to areas of higher concentration.
C. in any direction.
D. in whatever direction they are pumped.

(5.7, A)

74. A physical process requiring no input of energy and used by cells to exchange many materials with the environment is:

A. active transport.
B. osmosis.
C. diffusion.
D. secretion.

(5.7, C)

75. Materials that are admitted through a cell membrane are not always passed through the membrane according to the smallness of their size. This means that the membrane is:

A. differentially permeable.
B. freely permeable.
C. nonpermeable.
D. porous and permeable.

(5.7, A)

The next 10 items refer to the table of concentrations of substances in the cells of a certain seaweed, in seawater and in brackish water.

(5.7, AI)

	Typical concentrations		
Substance	**Maintained in seaweed cell**	**Found in seawater**	**Found in brackish water**
Calcium	1.700	12.0	1.7
Magnesium	0.005	57.0	6.5
Sulfate	0.010	36.0	2.8
Sodium	90.0	500.0	60.0
Potassium	490.0	12.0	1.4
Chlorine	500.0–600.0	520.0	73.0

The next six items relist the substances in the table. Use the following key to indicate the mechanism by which each substance enters or leaves the cells of the seaweed when the seaweed is in seawater.

KEY: A. diffusion
B. active transport into the cell
C. active transport out of the cell
D. osmosis

____ 76. magnesium:

(C)

____ 77. sodium:

(C)

____ 78. potassium:

(B)

____ 79. chlorine:

(A)

____ 80. calcium:

(C)

____ 81. sulfate:

(C)

82. Which substance enters the cell by active transport in brackish water but probably enters or leaves the cell by diffusion in seawater?

A. calcium
B. chlorine
C. sodium
D. sulfate

(B)

83. Which substances are actively transported out of the cell in both seawater and brackish water?

A. calcium and potassium
B. chlorine and sodium
C. magnesium and sulfate
D. sodium and sulfate

(C)

84. Which substance apparently enters or leaves the cell by diffusion in brackish water but leaves the cell by active transport in seawater?

A. calcium
B. chlorine
C. sulfate
D. sodium

(A)

85. Which substance enters the cell by active transport in brackish water and leaves the cell by active transport in seawater?

A. calcium
B. magnesium
C. sodium
D. sulfate

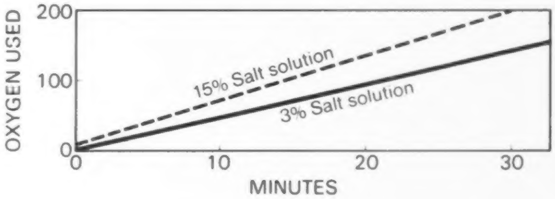
(C)

The next three items refer to the following information and graph.

(5.7, AI)

Some organisms can survive in water of widely different salt concentrations. Brine shrimp are an example. They maintain a constant concentration of salt in their bodies no matter what the concentration of the salt in the water around them. They survive in water containing from 0.5% to 25% salt.

The investigator who graphed the data below used the amount of oxygen taken up by the brine shrimp as an indication of how much food energy they were using, in water of two different salt concentrations. Food was supplied in unlimited amounts to both groups of the brine shrimp. The investigator observed that brine shrimp in 15% salt solution swam somewhat less actively than brine shrimp in 3% salt solution. Females in 15% salt solution produced fewer eggs than females in 3% salt solution.



86. What hypothesis could the investigator have been testing?

A. Brine shrimp in a 3% salt solution maintain a uniform concentration of salt in their bodies.
B. Brine shrimp in a 3% salt solution use much of their available energy pumping out water.
C. Brine shrimp in a 15% salt solution maintain a uniform concentration of salt in their bodies.
D. Brine shrimp in a 15% salt solution use much of their available energy pumping out salt.

(D)

87. What do the data show?

A. Brine shrimp eggs cannot survive in a 15% salt solution.
B. Brine shrimp in a 15% salt solution use more energy but are more sluggish than brine shrimp living in a 3% salt solution.
C. Brine shrimp in a 3% salt solution use less energy searching for food than brine shrimp in a 15% salt solution.
D. Brine shrimp in a 15% salt solution use less energy and are less active than brine shrimp in a 3% salt solution.

(B)

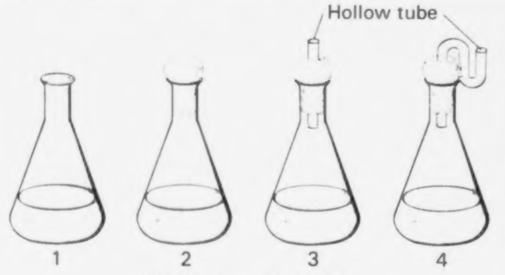
88. From the data, what conclusion is the investigator justified in forming?

A. Brine shrimp in 15% salt solution would starve in nature, since other organisms could not survive in water of that salt concentration.
B. Brine shrimp living in water of 0.5% salt content could probably live anaerobically, that is, without oxygen.
C. Brine shrimp in 15% salt solution actively transport salt out of their bodies using energy that otherwise could have supported other activities.
D. Brine shrimp use more energy actively transporting water out of their bodies than actively transporting salt out of their bodies.

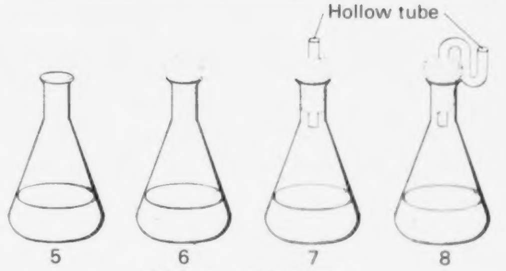
(C)

The next nine items refer to the following diagram and information.

(5.9, AI)



GROUP I UNTREATED



GROUP II STERILIZED

Flasks 1 through 8 were half-filled with a broth that supports the growth of microorganisms. Cotton stoppers were applied as shown. Group I was treated no further and was allowed to stand at room temperature on a laboratory table. Group II was sterilized in an autoclave and placed next to Group I.

89. Flask I serves primarily as a control for Flasks:

A. 2 and 6.
B. 5 and 7.
C. 7 and 8.
D. 2 and 5.

(D)

90. Microorganisms are most likely to appear first in Flask:

A. 1 or 5.
B. 1 or 6.
C. 2 or 6.
D. 4 or 8.

(A)

91. If all organisms are killed by sterilization, no growth should appear in Flask:

A. 4.
B. 5.
C. 6.
D. 7.

(C)

92. The hypothesis that all life comes from life would be best supported if no microorganisms appear in Flasks:

A. 3 and 5.
B. 4 and 5.
C. 4 and 7.
D. 6 and 8.

(D)

93. Spontaneous generation would be best supported if microorganisms appear in:

A. any flask.
B. Flasks 3 and 4.
C. Flasks 5 and 7.
D. all flasks.

(D)

94. If Flask 5 becomes cloudy before Flask 7, this cloudiness probably would be due to:

A. Flask 7 having a smaller opening to the outside.
B. Flask 7 being heated for a longer time than Flask 5.
C. no air getting into Flask 7.
D. the broth in Flask 5 being contaminated before heating.

(A)

95. The hypothesis that microorganisms enter the broth only from the air would be best supported if these organisms appear in Flasks:

A. 1 and 8.
B. 5 and 6.
C. 5 and 7.
D. 6 and 8.

(C)

96. If microorganisms grow in Flask 2, they most likely:

A. arise spontaneously.
B. come from air outside the flask.
C. were in the broth poured into the flask.
D. come off the wall of the flask.

(C)

97. If microorganisms grow in Flask 7, they most likely:

A. arise spontaneously.
B. come from air outside the flask.
C. were in the broth poured into the flask.
D. come off the wall of the flask.

(B)

---

98. In which of the following cubes would the movement of materials in and out be most efficient?

A. 1 cm
B. 2 cm
C. 4 cm
D. 8 cm

(5.9, inv. 5.3, A)

99. What is the surface area of a cube that measures 3 cm on each side?

A. 16 cm^2
B. 34 cm^2
C. 54 cm^2
D. 96 cm^2

(5.9, inv. 5.3, C)

100. What is the volume of a cube that measures 3 cm on each side?

A. 16 cm^3
B. 27 cm^3
C. 48 cm^3
D. 96 cm^3

(5.9, inv. 5.3, B)

101. What is the ratio of surface area to volume for a cube that measures 3 cm on each side?

A. 8:1
B. 4:1
C. 3:1
D. 2:1

(5.9, inv. 5.3, D)

102. Which of the following best explains why cells usually are very small?

A. The vacuoles in cells can hold only a limited amount of waste material.
B. Materials move in and out of small cells more easily.
C. Whenever a cell grows very large, it divides into two cells.
D. The cell membrane encloses the cell and prevents its growth.

(5.9, inv. 5.3, AI, B)

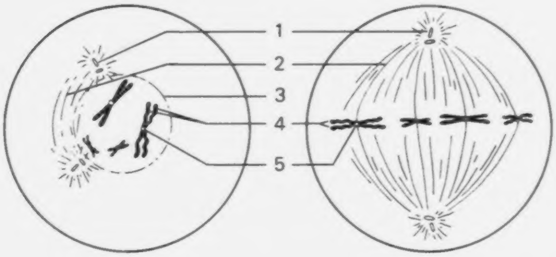
103. The separation of daughter chromosomes and division of a cell nucleus to form two nuclei, each with a full set of chromosomes, is called:

A. cell division.
B. cyclosis.
C. differentiation.
D. mitosis.

(5.10, D)

The next five items refer to the following diagrams of two stages in mitosis.

(5.11, AI)



104. Which structures first move apart during mitosis?

A. 1
B. 2
C. 3
D. 4

(A)

105. Which structure disappears when Structure 2 is forming?

A. 1
B. 2
C. 3
D. 4

(C)

106. How many chromatids are shown?

A. 2
B. 4
C. 6
D. 8

(D)

107. How many chromosomes will each nucleus have?

A. 2
B. 4
C. 6
D. 8

(B)

108. Which structure divides last as the chromosomes are about to be distributed to opposite ends of the cell?

A. 1
B. 2
C. 4
D. 5

(D)

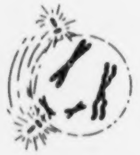
109. A certain cell's nucleus has 16 chromosomes before mitosis. How many chromosomes will each new cell nucleus have?

A. 4
B. 8
C. 16
D. 32

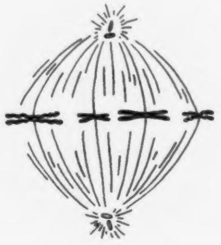
(5.11, AI, C)

The next eight items ask you to identify the mitotic stages in the following diagram.

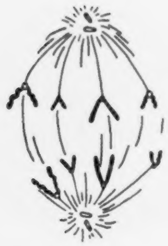
(5.11)



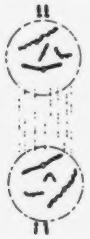
A



B



C



D

____ 110. when the chromosomes begin to coil, the spindle forms, and the nuclear envelope disappears:

(A)

____ 111. the daughter chromosomes move to opposite poles:

(C)

____ 112. the nuclear envelope and nucleolus reform:

(D)

____ 113. the chromosomes move to the center of the cell (the equatorial plane) and each chromosome strand (chromatid) becomes attached to the spindle:

(B)

____ 114. metaphase:

(B)

____ 115. telophase:

(D)

____ 116. prophase:

(A)

____ 117. anaphase:

(C)

---

118. How do cancer cells differ from normal cells?

A. all of the following
B. Cancer cells are foreign to the body and do not divide.
C. Cancer cells lack ribosomes.
D. Cancer cells lose control over their growth and cell division.

(5.12, D)

119. In multicellular organisms, new cells change in form and function as they mature, by a process called:

A. cloning.
B. cyclosis.
C. differentiation.
D. mitosis.

(5.12, C)

Chapter 6
Continuity through Reproduction

1. Reproduction is a process of greatest value to the:

   A. individual.
   B. niche.
   C. population.
   D. species.

   (6.1, AI, D)

2. For species of organisms, reproduction solves the problem of:

   A. habitats.
   B. immigration.
   C. individual differences.
   D. individual mortality.

   (6.1, AI, D)

3. Asexual reproduction is called vegetative reproduction when new organisms develop from:

   A. body parts of other organisms.
   B. cells with nuclei produced by meiosis.
   C. seeds that have been dormant.
   D. unfertilized animal or plant ova.

   (6.2, A)

4. Asexual reproduction is:

   A. equally common in animals and plants.
   B. less common in animals than plants.
   C. more common in animals than plants.
   D. rare in both animals and plants.

   (6.2, B)

5. Sexual reproduction involves:

   A. budding.
   B. one kind of cell.
   C. two different cells.
   D. regeneration.

   (6.2, C)

The next four items are based on the following reading.

(6.3, AI)

In several families of tropical fish, sex reversal is common. It has been observed in the "cleaner fish," *Labroides dimidiatus*. A research team studied 11 groups of *Labroides*. Each group had one adult male, three to six adult females, and a few immature females. The male defended a territory. There was a social hierarchy of male, Female 1, Female 2, Female 3, and so on. The females had individual feeding areas within the territory.

Occasionally one of the males died. Within one to two hours, Female 1 in that group showed aggressive behavior typical of the male. Within two to four days, she exhibited male mating behavior. Fourteen to eighteen days after the beginning of this sex reversal, the new "male" could produce sperm.

Would removing the male from the group cause sex reversal in Female 1? In 21 instances of removing the male, Female 1 always underwent sex reversal.

If a male were placed in the group as a new "male" was developing, would the new "male" continue the reversal? In four cases the new "male" did not complete the change. She again became a fully functioning female. And the introduced male took over control of the group.

In the fifth case, however, things went differently. An original male died. Another male was introduced. Female 1 went through three changes: She became a new "male," then a female, and then a new "male." After this final change, the new "male" chased the introduced male from the territory.

6. The most convincing evidence for actual sex reversal is the new "male's":

   A. aggressive behavior.
   B. courtship behavior.
   C. external appearance.
   D. production of sperm.

   (D)

7. The stimulus for production of a new "male" appears to be:

   A. absence of a male from the group.
   B. aggression by a male from another group.
   C. onset of the mating season.
   D. overabundance of females in the group.

   (A)

8. If both the male and Female 1 were removed from the territorial group, what would you expect to happen?

   A. The group would remain without a male.
   B. The remaining females would leave and join neighboring groups.
   C. Female 2 would begin reversal to male form.
   D. An extra male from another group would take over.

   (C)

9. Which of the following questions was answered when a male was introduced into a group where a female was undergoing sex reversal?

   A. Can a female in the process of becoming a new "male" change back into a functioning female?
   B. Will a male introduced into a group having a functioning male become a functioning female?
   C. Does sex reversal in females occur during some seasons but not others?
   D. In situations of environmental stress will both Female 1 and Female 2 become new "males"?

   (A)

---

10. Which best defines sex? Differences in size:

    A. and function of gametes
    B. and shape of reproductive organs
    C. of the chromosomes in the cells
    D. of the organisms

    (6.4, A)

11. The union of a sperm and an ovum is known as:

    A. fertilization.
    B. ovulation.
    C. parthenogenesis.
    D. regeneration.

    (6.5, A)

12. The union of a sperm and an ovum produces a:

    A. gamete.
    B. follicle.
    C. spore.
    D. zygote.

    (6.5, D)

13. Among animals, a new sexually reproduced individual begins with the union of two:

    A. diploid cells.
    B. haploid cells.
    C. haploid parents.
    D. unlike zygotes.

    (6.6, B)

14. The occurrence of meiosis preceding sexual reproduction normally prevents:

    A. cross-fertilization or cross-pollination.
    B. new individuals from being diploid.
    C. gametes from being haploid.
    D. new individuals from increasing their chromosome number.

    (6.6, AI, D)

15. A pair of chromosomes that are similar and contain the same kind of genes describes:

    A. gametes.
    B. genomes.
    C. homologs.
    D. zygotes.

    (6.6, C)

16. The result of meiosis is that each new cell nucleus has:

    A. different numbers and types of chromosomes.
    B. double the number of chromosomes of the parent cell.
    C. half the number of chromosomes of the parent cell.
    D. the same number of chromosomes as the parent cell.

    (6.6, C)

17. In cells of the gonads, chromosomes duplicate and the cell nucleus divides twice to produce four nuclei, each with half the number of chromosomes of the parent nucleus. This process is called:

    A. cell division.
    B. differentiation.
    C. meiosis.
    D. mitosis.

    (6.8, C)

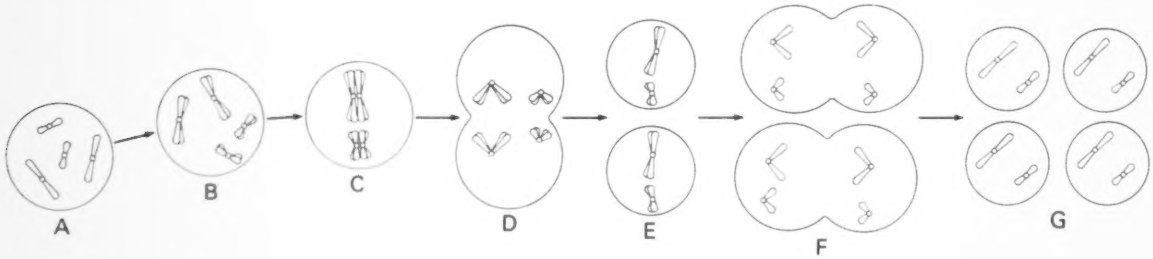
18. Meiosis is a process in which homologous chromosomes are:

    A. paired in the ovum.
    B. paired in the sperm.
    C. separated in different cell nuclei.
    D. united in the same cell nucleus.

    (6.8, C)

The next seven items are based on the following diagram of a cell process.

(6.9–6.10, AI)



19. What kinds of cells are represented at G?

    A. body cells
    B. gametes
    C. protists
    D. spores

    (B)

20. What is the diploid number of chromosomes?

    A. 2
    B. 4
    C. 6
    D. 8

    (B)

21. Which stage of this process is represented by D?

    A. Anaphase I
    B. Anaphase II
    C. Metaphase II
    D. Telophase I

    (A)

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22. Which stage of this process does E represent?

A. Anaphase II
B. Metaphase I
C. Metaphase II
C. Telophase II

(C)

23. The chromosomes shown in C are often called:

A. analogs.
B. chromatids.
C. homologs.
D. tetrads.

(D)

24. The process illustrates the changes during:

A. differentiation.
B. fertilization.
C. meiosis.
D. mitosis.

(C)

25. This process occurs in:

A. gonads.
B. pollen tubes.
C. spores.
D. zygotes.

(A)

---

26. How does gamete formation differ in male and female humans?

A. all of the following
B. Gamete formation is controlled by hormones in females, but not in males.
C. Gamete formation and meiosis stops earlier in males.
D. Meiosis is interrupted in females, but not in males.

(6.11–6.13, D)

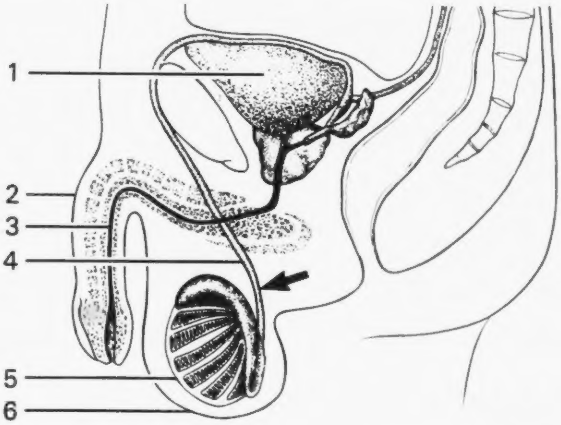
27. In animals, sperm and ova are produced in:

A. gonads.
B. ovaries.
C. oviducts.
D. testes.

(6.11, A)

The next four items are based on the following diagram of the male reproductive system.

(6.11)



28. The structure that produces sperm is number:

A. 2.
B. 3.
C. 4.
D. 5.

(D)

29. The structure used by both the reproductive and excretory systems is number:

A. 2.
B. 3.
C. 4.
D. 5.

(B)

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30. The structure that produces hormones is number:

A. 1.
B. 2.
C. 5.
D. 6.

(C)

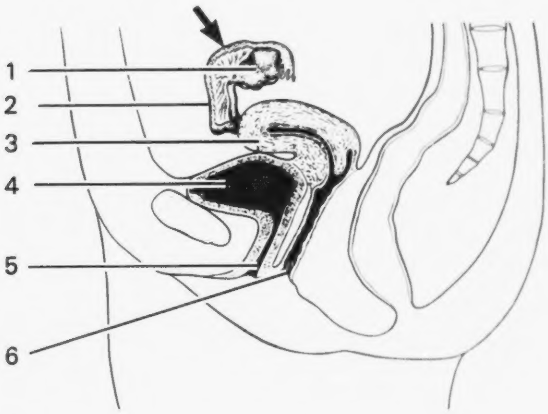
31. If structure 4 was cut and tied off at the arrow, which of the following would occur?

A. Hormones would no longer be produced.
B. Sperm would no longer be produced.
C. Sperm would no longer be released from the body.
D. Urine would no longer be released from the bladder.

(C)

The next eight items are based on the following diagram of the female reproductive system.

(6.13)



32. Ova are produced in structure number:

A. 1.
B. 2.
C. 3.
D. 4.

(A)

33. The human embryo develops in structure number:

A. 2.
B. 3.
C. 4.
D. 5.

(B)

34. The structures used by the urinary system are numbers:

A. 1 and 2.
B. 2 and 3.
C. 3 and 4.
D. 4 and 5.

(D)

35. The menstrual flow comes from the wall of structure number:

A. 1.
B. 2.
C. 3.
D. 5.

(C)

36. Fertilization of the human ovum occurs in structure number:

A. 1.
B. 2.
C. 4.
D. 6.

(B)

37. Sperm are deposited in structure number:

A. 2.
B. 4.
C. 5.
D. 6.

(D)

38. The structures directly involved in the birth of a baby are numbers:

A. 1 and 6.
B. 2 and 5.
C. 3 and 6.
D. 4 and 5.

(C)

39. If structure 2 was cut and tied off at the arrow, which of the following would occur?

A. The corpus luteum could not produce progesterone.
B. The follicles could not release ova.
C. Menstruation could not occur.
D. Ova could not reach the uterus.

(D)

---

40. Menstruation is the:

A. conversion of a ruptured follicle into a corpus luteum.
B. movement of the egg through the reproductive system.
C. periodic loss of blood and tissue from the uterus.
D. stopping of hormone production from the gonads.

(6.13, C)

41. In females, the thickening of the uterine wall is promoted by:

A. epinephrine and secretin.
B. estrogen and progesterone.
C. secretin and estrogen.
D. pituitary growth hormone.

(6.13, B)

42. In human females, the uterine lining is built up and maintained, or sloughed off in menstruation, in direct correlation with high or low levels of the hormones:

A. estrogen and secretin.
B. FSH and LH.
C. LH and secretin.
D. progesterone and estrogen.

(6.13, D)

43. How does the formation of eggs and sperm differ?

A. Hormones are involved only in egg formation.
B. An egg formation only results from one meiotic division.
C. Only one egg results from meiosis.
D. Sperm result from mitosis, eggs result from meiosis.

(6.14, C)

44. If only one human sperm fertilizes an egg, why are millions released?

A. Overkill; it is a waste.
B. The chances of one sperm reaching the egg are less than 1 in a million.
C. They provide food for the egg.
D. Their enzymes are needed to dissolve away the membranes around the egg.

(6.14, AI, D)

45. The animal fluid in which sperm are released is called:

A. endosperm.
B. estrogen.
C. semen.
D. testosterone.

(6.14, C)

46. Fertilization in humans normally occurs when the ovum is in the:

A. fallopian tube.
B. follicle.
C. uterus.
D. vagina.

(6.14, A)

47. How are the reproductive patterns of flowering plants and mammals alike?

A. Body cells are monoploid.
B. Fertilization is internal.
C. Individuals are of a single sex.
C. Offspring develop externally.

(6.15, AI, B)

48. In flowering plants, a new sexually reproduced individual begins with the union of two:

A. diploid cells.
B. diploid nuclei.
C. haploid nuclei.
D. unlike spores.

(6.15, C)

Chapter 7
Continuity through Development

1. What happens following fertilization in most animals?
   - A. all of the following
   - B. Meiosis in the egg is completed.
   - C. The diploid condition is restored.
   - D. The zygote divides.

   (7.1, A)

2. Why does a chicken egg have more yolk than a human egg?
   - A. A chicken embryo requires more food than a human embryo.
   - B. A chicken embryo is not nourished by its mother's body.
   - C. A hen's placenta is smaller than a human placenta.
   - D. A human embryo develops more rapidly than a chick embryo.

   (7.1, B)

3. What happens following fertilization in most animals?
   - A. all of the following
   - B. The zygote divides by mitosis and cytokinesis.
   - C. The embryo grows rapidly.
   - D. The haploid condition is restored.

   (7.1, B)

4. During development the cells of an embryo must:
   - A. stop mitosis or an abnormal growth will result.
   - B. organize into specialized structures.
   - C. go from inside to outside the embryonic cell mass.
   - D. reduce their chromosome number by half.

   (7.1, B)

5. The fertilized egg is a single cell containing:
   - A. two distinct nuclei.
   - B. chromosomes of only the female parent.
   - C. chromosomes from both sperm and egg.
   - D. One nucleus and a monoploid set of chromosomes.

   (7.1, C)

Use the following descriptions of investigations to answer the next 11 items.

(7.1, AI)

Investigation 1. Single ova of salamanders were tied loosely through the center so that the nucleus was held in one half of the ovum. A sperm nucleus entered each half. The thread was pulled more tightly, separating the ovum into two parts with a sperm in each, and the egg nucleus in one. Each part developed into an adult.

Use the key to identify the statements given in each of the following items.

KEY: A. interpretation consistent with the data
B. interpretation contrary to the data
C. insufficient evidence to evaluate the interpretation
D. not an interpretation, but a restatement of the data

___ 6. Development cannot take place unless ovum and sperm unite:

(B)

___ 7. The presence or absence of cytoplasm is not important:

(C)

___ 8. The two halves of the constricted ovum developed into adults:

(D)

___ 9. The entry of a sperm into the ovum is necessary for development to begin:

(A)

Investigation 2. Unfertilized salamander ova were divided into two sets. One set was untreated. The ova in the other set were pricked with a needle that had been dipped into the adult organism's blood. The unfertilized ova that were pricked with the needle developed into adults. The other ova soon died.

Use the same key to identify the following statements, which refer to information from both Investigations 1 and 2.

____ 10. The sperm nucleus is necessary for development:

(B)

____ 11. The presence or absence of cytoplasm is not important:

(C)

____ 12. A gamete nucleus is necessary for development to be completed:

(A)

____ 13. Some type of organic material introduced into the cell appears necessary for development to begin:

(A)

Investigation 3. Salamander ova were fertilized. The nuclei were removed. The zygotes died.

Use the same key to identify the following statements, which are based on Investigations 1, 2, and 3.

____ 14. The cytoplasm alone can produce an embryo:

(B)

____ 15. Some interaction between a nucleus and cytoplasm is necessary for development of the embryo:

(C)

____ 16. A nucleus is essential for the development of a salamander ovum into an embryo:

(A)

The next four items use the following terms as responses. Any one term may be used more than once or not at all.

(7.2)

KEY: A. blastula
B. gastrula
C. neural tube
D. zygote

____ 17. the hollow ball of cells resulting from cleavage:

(A)

____ 18. the stage at which a new cavity (the future gut) and 3 germ layers are formed:

(B)

____ 19. results from a folding over of ectodermal ridges and a fusion of the ridges:

(C)

____ 20. direct result of the fusion of gametes:

(D)

---

21. The first cell divisions of an animal zygote are called:

A. cleavage.
B. differentiation.
C. meiosis.
D. pregnancy.

(7.2, A)

22. At an early stage, an animal embryo forms a hollow ball of cells called a:

A. blastula.
B. fetus.
C. follicle.
D. gametophyte.

(7.2, A)

23. How is the vertebrate nervous system formed?

A. The dorsal mesoderm rolls up into a tube under the ectoderm.
B. The dorsal ectoderm thickens into two ridges which fuse into a tube under the epidermis.
C. The ventral ectoderm thickens into a solid rod which sinks under the skin.
D. The ventral mesoderm thickens into a solid rod under the epidermis.

(7.3, B)

The next four items use the following germ layers as responses. Match the structure or system with the one germ layer from which it forms. Any one germ layer may be used more than once or not at all.

(7.4)

KEY: A. ectoderm
B. endoderm
C. mesoderm

____ 24. the vertebrate nervous system:

(A)

____ 25. the lining of the intestines and lungs:

(B)

____ 26. the muscular system:

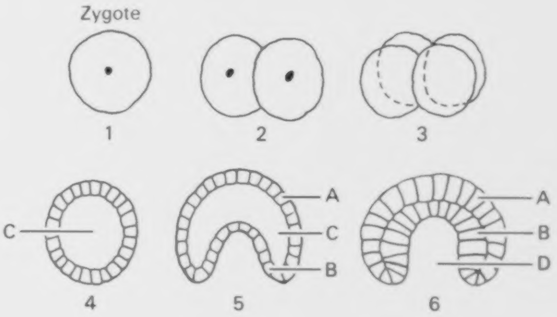
(C)

____ 27. the circulatory system:

(C)

The next three items are based on the following diagrams of embryonic development.

(7.4, AI)



28. Cavity D in stage 6 will become:

A. the spinal cord.
B. the digestive cavity.
C. filled with tissue.
D. the body cavity.

(B)

29. Between stages 1 and 2:

A. the egg and sperm will fuse.
B. the chromosomes will undergo mitotic division.
C. the chromosome number will be reduced by one half.
D. major differentiation will occur.

(B)

30. The cells of layer A will give rise to which system?

A. nervous
B. reproductive
C. digestive
D. circulatory

(A)

---

31. The embryos of most terrestrial animal species are protected against drying out by:

A. enclosure in liquid-filled membranes.
B. moisture in the soil where eggs were laid.
C. surrounding pond or ocean water.
D. waterproof deposits on the embryonic ectoderm.

(7.5, A)

32. The removal and analysis of fluid immediately surrounding a human fetus is called:

    A. abortion.
    B. amniocentesis.
    C. cesarean section.
    D. contraception.

    (7.6, B)

33. In mammals, specialized structures produced by the embryonic membranes join with an outgrowth of the mother's uterine wall to form the:

    A. abdominal organs of the embryo.
    B. appendage buds of the embryo.
    C. placenta and umbilical cord.
    D. yolk supply used during pregnancy.

    (7.6, C)

34. In mammals, a hollow ball of cells with a central mass of cells develops. This is comparable to which stage in other vertebrates?

    A. blastula
    B. gastrula
    C. neural tube stage
    D. zygote

    (7.6, A)

For the next three questions, match the following embryonic membranes with their descriptions or functions.

(7.6)

KEY: A. allantois
B. amnion
C. chorion
D. yolk sac

____ 35. In mammals, it forms the embryonic part of the placenta:

(C)

____ 36. In mammals, it surrounds the embryo and becomes filled with a liquid:

(A)

____ 37. In birds, it surrounds the material that nourishes the embryo:

(D)

---

38. Which best describes the relationship between the blood supply of a human fetus and its mother?

    A. Blood flows from one into the other.
    B. Their blood systems are separate and no materials are exchanged.
    C. Their blood systems are separate but some materials may pass from one to the other.
    D. Their blood systems are separate only at certain times in development and connected at other times.

    (7.7, AI, C)

39. When is the developing embryo most sensitive to harmful agents? During:

    A. the first trimester
    B. the second trimester
    C. the third trimester
    D. all stages equally

    (7.7, A)

40. A fetus is:

    A. a human embryo after the first 3 months (12 weeks).
    B. a human embryo during the first 3 months (12 weeks).
    C. the blastula stage in human development.
    D. the gastrula stage in human development.

    (7.7, A)

41. Which method of birth control depends on providing a barrier between sperm and eggs?

    A. all of the following
    B. condom
    C. pill
    D. vasectomy

    (7.9, B)

42. Which method of contraception depends on preventing ovulation? The

    A. condom
    B. diaphragm
    C. pill
    D. vasectomy

    (7.9, C)

43. A group of similar cells that carry out the same function in a multicellular organism is called a:

A. clone.
B. closed system.
C. spindle.
D. tissue.

(7.11, D)

44. Cancer is treated by chemotherapy or radiation, both of which kill cells that rapidly divide. Which of the following is an undesirable side effect and why?

A. brain damage because nerve cells do not divide
B. digestive upsets because the cells lining the digestive tract are continually replaced
C. inability of the blood to carry oxygen because the red blood cells rapidly divide
D. muscle disorders because muscle cells rapidly divide

(7.11–7.12, AI, B)

45. What seems to happen with cancer cells? Their:

A. cell divisions stop.
B. cell growth and division becomes uncontrolled.
C. development becomes very specialized and limited.
D. differentiation is speeded up drastically.

(7.12, B)

The next eight items are based on the following key and information.

(7.4–7.12, AI)

KEY: The three processes of growth and development are
A. cell division
B. cell enlargement
C. cell differentiation

Identify each phrase below, indicating which process is best described.

____ 46. cleavage of the fertilized egg:
(A)

____ 47. process limited by the other two processes of growth and development:
(B)

____ 48. muscle cells, nerve cells, and skin cells:
(C)

____ 49. formation of the blastula:
(A)

____ 50. formation of neural folds:
(C)

____ 51. a reason that food is necessary:
(B)

____ 52. new feature at gastrula stage:
(C)

____ 53. cancer:
(A)

Chapter 8
Continuity through Heredity

1. In probability, the chance of an independent event occuring:
   - A. cannot be predicted with any confidence.
   - B. depends on previous events.
   - C. is dependent on the probability that a dependent event occurs.
   - D. is unaffected by other events.

   (8.3, D)

2. How many combinations of one head and one tail would you expect if two coins were tossed together 40 times?
   - A. 5
   - B. 10
   - C. 15
   - D. 20

   (8.3, AI, D)

3. Probability in genetics deals mainly with determining:
   - A. actual outcomes of events.
   - B. causes of different events.
   - C. predicted outcomes of events.
   - D. sources of unexpected events.

   (8.3, C)

4. Why were garden peas good experimental organisms for Mendel's experiments? They:
   - A. are large and slow growing.
   - B. can easily self or cross pollinate.
   - C. had never been studied before Mendel and only hybrids were available.
   - D. have a complicated heredity.

   (8.4, B)

The next five items refer to the following cross in garden peas.

(8.4, AI)

P_1 cross	F_1 plants	F_2 plants
Round seeds X wrinkled seeds	All offspring round	5474 round 1850 wrinkled

Use this key to identify the plants referred to in each question.

KEY: A. P_1 plants
B. F_1 plants
C. F_2 plants

____ 5. Which generation is considered true-breeding?

(A)

____ 6. From the individuals of which generation did Mendel develop the concept of dominance?

(B)

____ 7. From which generation did Mendel develop the idea of the recessive trait?

(C)

____ 8. Which generation indicates the hybrids?

(B)

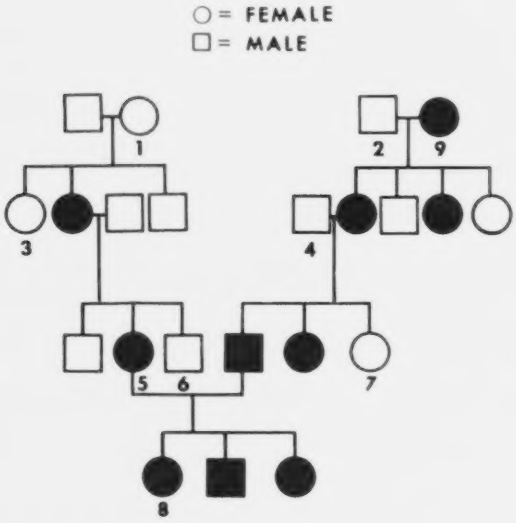
____ 9. From which generation did Mendel develop the idea of segregation?

(C)

The next five items are based on the following information and pedigree.

(8.4, AI)

One type of severe familial myopia (extreme nearsightedness) is caused by a dominant gene. A pedigree involving this trait is shown below. Afflicted individuals are shown in black; the other individuals are not myopic.



Use the following key to answer the next four items.

KEY: A. homozygous
B. heterozygous
C. insufficient information to determine genotype

____ 10. What is the genotype of Individual 1?

(A)

____ 11. What is the genotype of Individual 2?

(B)

____ 12. What is the genotype of Individual 8?

(C)

____ 13. If Individual 9 marries a woman of normal vision, what will be the genotype of the first offspring?

(C)

14. If Individuals 6 and 7 marry, what will be the expected percentage of their offspring to have the myopic trait?

A. 0%
B. 10%
C. 25%
D. 50%

(A)

15. Mendel's experiments differed from those of previous biologists *except* that he:

A. combined the results of identical experiments.
B. concentrated on many traits at a time.
C. used large numbers of organisms.
D. used probability rules to analyze the results.

(8.4, B)

16. An individual's genotype for an inherited trait is the:

A. family pedigree for the trait.
B. physical appearance caused by the trait.
C. set of alleles carried for the trait.
D. sex of the individual in relation to the trait.

(8.5, C)

The next three items are based on the following information.

(8.5, AI)

In peas, yellow seed (*Y*) is dominant to green seed (*y*), and round seed (***R***) is dominant to wrinkled (***r***).

17. How many kinds of gametes could be produced by a ***YYRr*** plant?

A. 1
B. 2
C. 3
D. 4

(B)

18. How many kinds of gametes could be produced by a ***YyRr*** plant?

A. 1
B. 2
C. 3
D. 4

(D)

19. How many kinds of gametes could be produced by a ***yyRR*** plant, the most common garden variety of pea?

A. 1
B. 2
C. 3
D. 4

(A)

---

20. Hybrid means the same as:

A. dominant.
B. heterozygous.
C. homozygous.
D. mutant.

(8.5, B)

21. Which of the following is a phenotype?

A. flowering pea plant
B. garden pea plant
C. long-stemmed pea plant
D. peas within pods

(8.5, C)

22. A gene whose effect remains hidden when it is paired with a different gene is called:

A. codominant.
B. dominant.
C. mutant.
D. recessive.

(8.5, D)

23. Different genes that affect the same single gene-pair trait are called:

A. alleles.
B. codominants.
C. dihybrids.
D. polygenes.

(8.5, A)

24. An individual in which the two genes of a pair that affect a particular trait are identical is said to be:

A. dihybrid.
B. heterozygous.
C. homozygous.
D. hybrid.

(8.5, C)

25. In Mendel's first experiment, pure-breeding plants with contrasting forms (characters) for one trait were crossed. Only one form (character) appeared in the hybrid F_1 offspring. What did this show?

A. One form was dominant over the other.
B. One inheritable unit (element) came from each parent.
C. The parents were not pure breeding.
D. The traits separate during gamete formation.

(8.5, AI, A)

26. Mendel then self-pollinated the F_1 generation and obtained an F_2 generation with both parental forms in the ratio of 3 to 1. What did this show?

A. One form was dominant over the other.
B. One inherited unit came from each parent.
C. The parents were not pure breeding.
D. The traits separate during gamete formation.

(8.5, AI, B)

27. How would you describe the P and F_1 plants in Mendel's first experiment in modern terms? The P plants were both:

A. heterozygous and the F_1 plants were homozygous.
B. heterozygous as were the F_1 plants.
C. homozygous and the F_1 plants were heterozygous.
D. homozygous as were the F_1 plants.

(8.5, AI, C)

28. Which law(s) of probability was (were) illustrated by the formation of the ¾ to ¼ ratio in the F_2?

    A. all of the following
    B. The chance of either of two independent events occuring is the sum of their separate probabilities.
    C. The chance of one independent event occuring is unaffected by previous independent events.
    D. The chance that 2 independent events occur together is the product of their separate probabilities.

    (8.5, AI, A)

29. Today geneticists refer to Mendel's true-breeding parent pea plants as:

    A. codominant for the traits in question.
    B. dominant for the traits in question.
    C. heterozygous for the traits in question.
    D. homozygous for the traits in question.

    (8.5, D)

30. The genetic makeup of an individual for a trait being studied is called that individual's:

    A. genotype.
    B. pedigree.
    C. phenotype.
    D. variability.

    (8.5, A)

31. Mendel arrived at the conclusion that the two elements affecting a particular trait are separated during gamete formation. This has since been confirmed by the discovery of:

    A. eggs and sperms.
    B. fertilization.
    C. meiosis.
    D. mitosis.

    (8.5, C)

32. An individual's genotype for an inherited trait is the:

    A. family pedigree for the trait.
    B. physical appearance caused by the trait.
    C. set of alleles carried for the trait.
    D. sex of the individual in relation to the trait.

    (8.5, C)

33. ***A*** represents the gene for a dominant characteristic and ***a*** its recessive allele. If an ***Aa*** individual mates with an ***aa*** individual:

    A. all offspring will be dominant.
    B. all offspring will be recessive.
    C. half the offspring will be dominant and half recessive.
    D. three quarters of the offspring will be dominant and one quarter recessive.

    (8.6, AI, C)

34. How many heterozygous offspring would you expect if two parents who were heterozygous for a trait produced an F_1 generation of 40 individuals?

    A. 5
    B. 10
    C. 15
    D. 20

    (8.6, AI, D)

35. Mendel's second experiment was a dihybrid cross in which he crossed two pure breeding parents with contrasting forms for two traits. The F_1 hybrids all showed the dominant form for both traits. When the F_1 was self-pollinated the F_2 offspring showed four phenotypes in the ratio of 9/16: 3/16: 3/16: 1/16. Which principle resulted from this experiment?

    A. dominance
    B. independent assortment
    C. linkage
    D. segregation of alleles

    (8.7–8.8, AI, B)

36. Mendel concluded that genes for two or more different traits assort independently of one another at gamete formation. He reached this conclusion because none of the garden pea traits he studied were:

A. codominant.
B. linked.
C. recessive.
D. visible.

(8.7, AI, B)

37. The inheritance of the blood groups A, B, AB, and O is an example of:

A. codominance.
B. multiple alleles.
C. polygenic inheritance.
D. simple dominance with one pair of alleles.

(8.9, B)

38. Few human characteristics appear to be determined by single pairs of genes. This means that human hereditary traits will be difficult to study until the:

A. chromosomes are accurately counted.
B. polygenes for each trait are identified.
C. replication of DNA can be analyzed.
D. ribosomal RNA can be decoded.

(8.9, AI, B)

39. Human blood type is determined by:

A. linked gene pairs.
B. multiple alleles.
C. polygenic inheritance.
D. a single gene.

(8.9, B)

40. What is the relationship between two unlike genes of a pair if they both express their effects on an individual's phenotype?

A. codominance
B. dominance
C. linkage
D. X-linkage

(8.9, A)

41. The relationship between the I^B allele for Type B blood and the i allele for Type O blood is:

A. codominance.
B. different loci.
C. dominant/recessive.
D. unknown.

(8.9, C)

42. The relationship between the I^A allele for Type A blood and the I^B allele for Type B blood is:

A. codominance.
B. different loci.
C. dominant/recessive.
D. unknown.

(8.9, A)

43. Mr. Sandival has Type B blood. Mrs. Sandival has Type O blood. They have three children of their own and one adopted child. Owen has Type AB blood, Mary Type O, Susie Type B, and Carl Type B. Which child is adopted?

A. Carl
B. Mary
C. Owen
D. Susie

(8.9, AI, C)

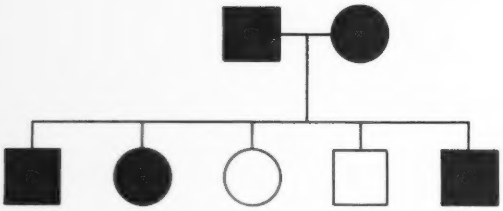
44. A homozygous red morning glory is crossed with a homozygous yellow-white one. The F_1 generation all show a blend of the parents' flower colors. This is an example of:

A. codominance.
B. multiple alleles.
C. mutation.
D. true breeding.

(8.9, AI, A)

The next four items are based on the following pedigree. Circles are females; squares males.

(8.9, AI)



45. The characteristic indicated in black appears to be:
    - A. codominant.
    - B. dominant.
    - C. recessive.
    - D. X-linked.

    (B)

46. What are the genotypes of the parents?
    - A. Both are heterozygous dominant.
    - B. Both are homozygous dominant.
    - C. Both are homozygous recessive.
    - D. The male is homozygous dominant; the female is homozygous recessive.

    (A)

47. Assume that human blood type is the characteristic shown, and that one parent is Type A and the other Type B. What are the blood types of the offspring?
    - A. One is A, one is AB, one is B, and two are O.
    - B. One is A, two are AB, and two are O.
    - C. Two are AB, one is B, and two are O.
    - D. Three are AB, and two are O.

    (D)

48. How does the information in Question 47 affect your answer to Question 46? The characteristics shown in black now appear to be:
    - A. codominant.
    - B. dominant.
    - C. recessive.
    - D. X-linked.

    (A)

The next three items refer to the information below.

(8.9, AI)

Identification bracelets were accidentally removed from three newborn babies. Blood typings were taken to help in the identification procedures. The blood types for the babies and their parents were:

Baby I—Type A
Baby II—Type O
Baby III—Type AB

Mr. Black—Type A
Mr. Brown—Type AB
Mr. White—Type O

Mrs. Black—Type B
Mrs. Brown—Type O
Mrs. White—Type O

49. Which baby could belong to Mr. and Mrs. Black?
    - A. Baby I
    - B. Baby II
    - C. Baby III
    - D. any of the three

    (D)

50. Which baby could belong to Mr. and Mrs. Brown?
    - A. Baby I
    - B. Baby II
    - C. Baby III
    - D. any of the three

    (A)

51. Which baby could belong to Mr. and Mrs. White?
    - A. Baby I
    - B. Baby II
    - C. Baby III
    - D. any of the three

    (B)

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52. In humans a child's sex is normally determined by:

    A. the father's gamete.
    B. the mother's gamete.
    C. nondisjunction of sex chromosomes.
    D. segregation of alleles at meiosis.

    (8.11, A)

53. A child with Down syndrome has 22 pairs of normal chromosomes and 3 chromosomes in place of the 23rd pair. This disorder is the result of:

    A. crossing over.
    B. independent assortment.
    C. mutation.
    D. nondisjunction in meiosis.

    (8.12, D)

54. Altered chromosomes can cause abnormalities in the embryo. An alteration resulting in reversal of a section of a chromosome is called:

    A. deletion.
    B. duplication.
    C. inversion.
    D. translocation.

    (8.12, C)

55. Human males have no alleles on their Y chromosome to pair with genes on their X chromosome. Thus, a single recessive gene on the X chromosome is expressed in the male. A trait caused by such a gene is known as:

    A. continuously variable.
    B. nondisjunct.
    C. polygenic.
    D. X-linked.

    (8.13, D)

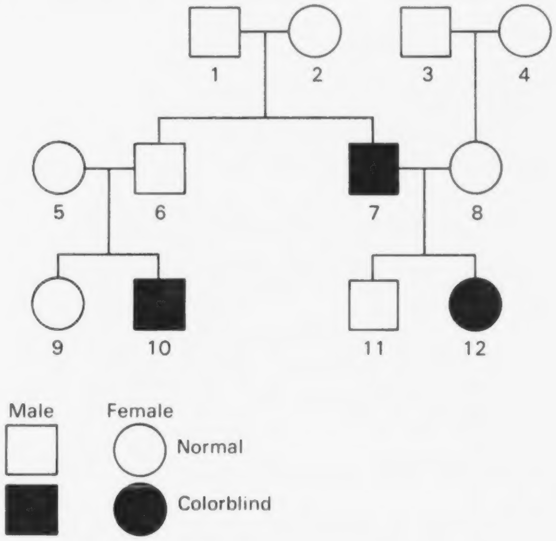
56. Human genes can be inserted into the hereditary material of bacteria, to cause the bacteria to make a needed human hormone. This technique is called:

    A. gene mutation.
    B. gene-splicing.
    C. hormone injection.
    D. independent assortment.

    (8.13, B)

The next seven questions are based on the following pedigree for the inheritance of X-linked colorblindness.

(8.13, AI)



Answer the question T or F for true or false.

____ 57. Individual 4 is a carrier of the allele for X-linked colorblindness:

(T)

____ 58. For Individual 12 to be colorblind, a homozygous recessive condition exists:

(T)

____ 59. Individual 1 is the carrier responsible for Individual 7:

(F)

____ 60. The four grandparents of Individual 12 are Individuals 1, 2, 3, and 4:

(T)

____ 61. Individual 5 is not a carrier of the allele for X-linked colorblindness:

(F)

____ 62. Individual 9 is the only person whose genotype for the trait is unknown:

(T)

____ 63. Individuals 10 and 12 illustrate one reason why cousins are discouraged from marrying. In this case their children would all be colorblind:

(T)

---

64. A pair of homologous chromosomes carry the gene combinations ***AB*** and ***ab,*** respectively, before meiosis. What types of gametes should be expected?

A. ***Ab*** and ***aB***
B. ***Ab*** and ***ab***
C. ***aB*** and ***ab***
D. ***ab*** and ***AB***

(8.14, D)

65. For a particular species of organism, more than 1000 hereditary traits were mapped. Many generations of breeding experiments showed that six linkage groups existed. You could infer that the body cells contained how many pairs of chromosomes?

A. 2
B. 3
C. 6
D. 12

(8.14, C)

66. What happens if a human male has one recessive X-linked gene, and why?

A. The dominant form is expressed because it is on the Y chromosome.
B. The dominant form is expressed because the second gene is dominant.
C. The recessive form is expressed because males have only X chromosome.
D. The recessive form is expressed because the male hormone suppresses the expression of the dominant gene.

(8.14, C)

67. Which underlies the mapping of chromosomes?

A. all of the following
B. Linked mutant genes for different traits can recombine if on homologous chromosomes.
C. Recombination frequencies are a measure of distances between genes.
D. The farther apart genes are on a chromosome, the more likely they are to cross over.

(8.14, A)

68. A pair of homologous chromosomes carry the gene combinations ***Ab*** and ***aB,*** respectively, before meiosis. How can an ***AB*** gamete be explained?

A. crossing over
B. independent assortment
C. nondisjunction
D. segregation of alleles

(8.14, AI, A)

69. Two traits are said to be linked when the genes that determine them are:

A. assorted independently in meiosis.
B. carried on the same chromosomes.
C. considered to produce desirable traits.
D. studied together in a dihybrid cross.

(8.14, B)

70. If a ***TtRr*** organism produces 1000 gametes and all are ***Tr*** or ***tR,*** then the two pairs of genes are probably:

A. linked.
B. multiple alleles.
C. mutations.
D. recessive.

(8.14, A)

71. Two genes linked on the same chromosome will be in the same gamete unless:

A. crossing over occurs.
B. meiosis occurs.
C. nondisjunction occurs.
D. replication occurs.

(8.14, A)

For the next three items use the key to explain the reported event. Assume that the F_1 generation was large enough to provide a valid sample.

(8.14, AI)

KEY: A. The genes are linked.
B. Crossing over occurred.
C. Nondisjunction occurred.

____ 72. In the cross ***AaBb*** × ***aabb,*** all the F_1 generation were of two genotypes:

(A)

____ 73. In the cross ***AaBb*** × ***aabb,*** the F_1 generation were of four genotypes in an 8:1:8:1 ratio:

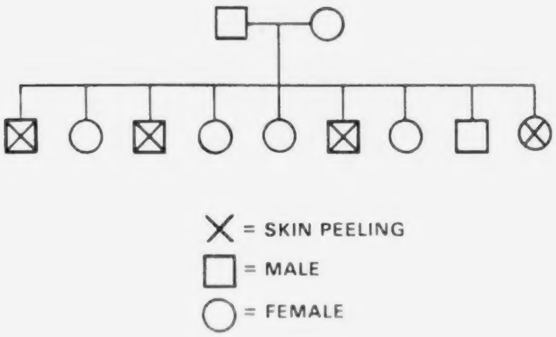
(B)

____ 74. In the cross ***AabB*** × ***aabb,*** six genotypes were produced as follows: ***AaBb, AaBbb, Aabb, aaBb, aabb,*** and ***aab:***

(C)

The next seven items are based on a pedigree started by a marriage between cousins. The trait designated by "X" was known only in isolated instances until it appeared in their F_1 generation. It is named "familial continuous skin peeling."

(8.14, AI)



Use the key to evaluate each hypothesis in the next seven items.

KEY: A. a hypothesis supported by the data
B. a hypothesis contradicted by the data
C. a hypothesis neither supported nor contradicted by the data

____ 75. Skin peeling appears to be a recessive trait:

(A)

____ 76. If the trait is not hereditary, it may be caused by something in the family's environment:

(C)

____ 77. The father is normal, yet children of both sexes have the trait, suggesting that the inheritance pattern is not X-linked:

(A)

____ 78. The probability that the trait is recessive is increased by the family relationship of the parents:

(A)

____ 79. The trait could be a dominant family trait unreported previously for personal reasons:

(B)

____ 80. The slight possibility that the trait is dominant lies in an identical mutation occurring four times in the gametes of one of the parents:

(A)

____ 81. Marriage of F_1 individuals to persons who are not related to them probably will end this pedigree before the F_2 generation:

(A)

82. Beadle and Tatum's work with *Neurospora* showed that:

A. genes control the synthesis of sugars.
B. genes control the synthesis of vitamins.
C. one gene controls the synthesis of one enzyme.
D. one gene controls the synthesis of several enzymes.

(8.15, A)

83. The genes in the chromosomes of most organisms are made of:

A. ADP.
B. ATP.
C. DNA.
D. RNA.

(8.16, C)

84. Which is evidence that DNA is the genetic material?

A. all of the following
B. Chromosomes contain DNA.
C. Dead bacteria of one strain can transform live bacteria of another strain by DNA.
D. Using radioactive isotopes, it was shown that DNA from viruses goes into bacteria cells.

(8.16, A)

85. By studying the results of the experiments with bacteria and some viruses, one can better interpret the role of DNA in higher forms of life because:

A. the DNA of the bacteria and viruses is present in the same amounts as in higher forms.
B. the chemical makeup of bacteria, viruses, and higher forms is similar.
C. only virus DNA is parasitic in the cells of multicellular organisms.
D. genetic activity of all higher organisms seems to be tied to DNA.

(8.16, AI, D)

The next ten items are based on the following data. Use the key to classify the statements.

(8.17, AI)

Source	Quantity of Nucleotides in DNA			
	Adenine	Thymine	Guanine	Cytosine
Calf	1.13	1.11	0.86	0.85
Rat	1.15	1.14	0.86	0.82
Moth	0.84	0.80	1.22	1.33
Virus	1.17	1.12	0.90	0.81
Sperm (of rat)	1.15	1.09	0.89	0.83

KEY: The data provide
A. evidence for this statement.
B. evidence against this statement.
C. no evidence for or against this statement.

____ 86. The DNA molecule contains four different nucleotides:

(A)

____ 87. Each nucleotide has only one other with which it can pair:

(A)

____ 88. A constant diameter of the DNA molecule is achieved by nucleotide pairing:

(C)

____ 89. Adenine nucleotide and guanine nucleotide form one pair:

(B)

____ 90. The ratio of adenine nucleotide to guanine nucleotide is fairly constant for all species:

(B)

____ 91. The ratio of adenine nucleotide to thymine nucleotide is about the same in the sperm of a rat as in its body cells:

(A)

____ 92. The amounts of adenine and thymine nucleotides in a cell always are greater than the amounts of guanine and cytosine nucleotides:

(B)

____ 93. The sources of the data suggest the hypothesis that adenine and thymine nucleotides pair with each other in all organisms:

(A)

____ 94. Adenine nucleotides pair with uracil nucleotides in RNA:

(C)

____ 95. A DNA codon consists of a chemically bonded chain of three of the four nucleotides, each unpaired:

(C)

---

96. DNA replicates by breaking the bonds between its two strands, after which each strand:

A. grows to double length.
B. synthesizes a new strand.
C. takes a spiral appearance.
D. winds back upon itself.

(8.17, B)

97. A nitrogenous base is bonded to the five-carbon sugar deoxyribose, which in turn is bonded to a phosphate. The molecule is one of many that make up:

A. DNA.
B. protein.
C. RNA.
D. ribosomes.

(8.17, A)

98. Which is *not* consistent with Watson and Crick's model for a DNA molecule?

A. Adenine pairs with thymine and cytosine pairs with guanine.
B. It is composed of two strands made up of nucleotides.
C. The strands are held together by strong chemical bonds between the sugars.
D. The strands are twisted into a helix.

(8.17, C).

99. If proteins are synthesized at the ribosomes, then:

A. radioactive amino acids should accumulate at the chromosomes.
B. radioactive amino acids should accumulate at the ribosomes.
C. radioactive DNA should accumulate at the ribosomes.
D. radioactive RNA should accumulate at the chromosomes.

(8.18, AI, B)

100. If codons consist of three adjacent nucleotides and code for 20 amino acids then:

A. more amino acids must be involved.
B. several amino acids have the same codon.
C. several codons are nonsense.
D. several codons code for each amino acid.

(8.18, AI, D)

101. The actual genetic code in genes appears to be:

A. chemical bonds in amino acids.
B. enzymes acting on ribosomal RNA.
C. protein chains in the cell nucleus.
D. triplet sequences of nucleotides in DNA.

(8.18, D)

102. The coded material that migrates from a cell nucleus to a ribosome where a particular polypeptide will be synthesized is called:

A. codon DNA.
B. messenger RNA.
C. ribosomal RNA.
D. transfer RNA.

(8.18, B)

103. How are the genetic messages transferred from the chromosome to the ribosomes?

A. DNA.
B. mRNA
C. rRNA
D. tRNA

(8.18, B)

104. A chemical change in a gene that causes the gene to produce a different effect is called a:

A. mutation.
B. nondisjunction.
C. recombination.
D. replication.

(inv. 8.4, A)

105. A chemical change in a gene that alters its hereditary effects is called a:

A. mutation.
B. nondisjunction.
C. recombination.
D. replication.

(inv. 8.4, A)

106. A gene can be isolated and attached chemically to the hereditary material of another organism in the technique called:

A. crossing over.
B. gene splicing.
C. independent assortment.
D. nondisjunction.

(8.20, B)

Chapter 9
Continuity through Evolution

1. Which is an application of the principle of "unity of pattern?"
   - A. A new cancer drug is tested on rats.
   - B. All plants we have studied have chloroplasts.
   - C. Each species of firefly has its own pattern of light flashes produced by a chemical reaction.
   - D. There are hundreds of different species of slime molds.

   (9.1, AI, A)

2. The *major* evidence that changes have occurred in species is the:
   - A. domestication of animals.
   - B. fossil record.
   - C. mortality of individuals.
   - D. variation among individuals.

   (9.1, B)

3. Lamarck offered the hypothesis that individuals with acquired characteristics could:
   - A. adapt to these characteristics.
   - B. displace more successful competitors.
   - C. pass these characteristics on to their offspring.
   - D. survive harmful genetic mutations.

   (9.2, C)

4. Darwin questioned Lamarck's hypothesis but, like Lamarck, could not satisfactorily explain:
   - A. change in the environment.
   - B. competition for survival.
   - C. evolution by natural selection.
   - D. hereditary characteristics.

   (9.2, D)

5. In looking for a method of evolution, Lamarck took special interest in the fact that individuals are changed by their:
   - A. experiences in the environment.
   - B. innate behavior.
   - C. phenotypes.
   - D. recessive alleles.

   (9.2, A)

6. Lamarck observed that organisms used certain abilities more than others in their environment. In this way they helped adapt themselves and acquired modified characteristics. However, little evidence has been found to support Lamarck's hypothesis that:
   - A. acquired changes occur in characteristics.
   - B. acquired changes in characteristics can be inherited.
   - C. heredity can modify the environment.
   - D. heredity can modify species as well as individuals.

   (9.2, B)

7. The theory of organic evolution originated with:
   - A. Darwin and Wallace.
   - B. Lamarck.
   - C. Lyell and Malthus.
   - D. unknown earlier naturalists.

   (9.2, D)

8. Credit for the theory of natural selection is usually given to:
   - A. Darwin and Wallace.
   - B. Lamarck and Lyell.
   - C. Malthus and Darwin.
   - D. Malthus and Wallace.

   (9.3, A)

The next six items refer to the following information.

(9.3, AI)

The ideas of the major theories in biology have sometimes occurred independently to different individuals at different times. References to evolution have been traced back to the early Greeks. Darwin and Wallace received credit for the theory of natural selection, but in the fourth edition of *On the Origin of Species by Means of Natural Selection* Darwin noted and credited an earlier naturalist's work.

Patrick Matthew was the earlier naturalist. In the year 1831, when young Charles Darwin sailed on the *Beagle*, Matthew published a little-known book from which the following quotations are taken:

Page 108: Matthew referred on this page to trees cultivated by humans and called them "so much inferior to those of Nature's own rearing, where only the stronger, more hardy, soil-suited varieties can struggle forward to maturity and reproduction."

9. This quotation refers to the concept that biologists know as:

   A. acquired characteristics.
   B. evolution.
   C. natural selection.
   D. survival of the fittest.

   (D)

Page 308: Matthew discussed varieties of the same families of plants and their unequal success in nature because of "a continual selection of the strongest, best circumstance-suited, for reproduction." In the next sentence he stated that human interference prevented "this natural process of selection among plants."

Page 365: Matthew stated that "those individuals who possess not the requisite strength, swiftness, hardihood, or cunning fall prematurely without reproducing."

Page 385: Matthew discussed animals and plants together and stated that "Nature tests their adaptation to her standard of perfection and fitness to continue their kind by reproduction."

10. These three quotations refer to the concept that Darwin and Wallace called:

    A. evolution.
    B. natural selection.
    C. survival of the fittest.
    D. variations in individuals.

    (B)

Page 381: Matthew discussed the concept of *species* and stated: "A particular conformity, each after its own kind, when in a state of nature termed species, no doubt exists to a considerable degree . . . Geologists discover a like particular conformity—fossil species—through the deep deposition of each great epoch, but they also discover an almost complete difference to exist between the species or stamp of life of one epoch from that of every other. We are therefore led to admit . . . of a power of change, under a change of circumstance. . ."

Page 382: "Is the inference therefore unphilosophic that living things . . . may have gradually accommodated themselves to the variations of the elements containing them. . . ?"

Page 384: " . . . the progeny of the same parents, under great difference of circumstance, might in several generations even become distinct species, incapable of coreproduction."

Page 387: "Among the millions of *specific varieties* of living things which occupy the humid portion of the surface of our planet, as far back as can be traced, there does not appear, with the exception of man, to have been any particular engrossing race, but a pretty fair balance of powers of occupancy—or rather, most wonderful variation of circumstance parallel to the nature of every species, as if circumstance and species had grown up together."

11. These four quotations refer to the concept that biologists today call the:

    A. fossil record.
    B. geological record.
    C. theory of evolution.
    D. theory of natural selection.

    (C)

12. From the data, it appears that the theory of natural selection may have originated with:

   A. Darwin.
   B. Malthus.
   C. Matthew.
   D. Wallace.

   (C)

13. From the data, it further appears that the theory of evolution may have originated with:

   A. Darwin.
   B. Greek philosophers.
   C. Matthew.
   D. Wallace.

   (B)

14. Biologists give the primary credit for new theories to the scientists who do the most to establish the theories and see them accepted. According to this standard, the person who deserves greatest credit for the theory of natural selection is:

   A. Darwin.
   B. Malthus.
   C. Matthew.
   D. Wallace.

   (A)

---

15. Why were the Galapagos Islands especially interesting to Charles Darwin?

   A. Extremely harsh conditions on the islands resulted in only a few different organisms.
   B. Related organisms were different on each island.
   C. The organisms on these isolated islands were totally different from those anywhere else.
   D. Unrelated organisms were similar on the different islands.

   (9.3, B)

16. The key idea in natural selection is that individuals with advantageous hereditary characteristics will:

   A. compete successfully.
   B. live to reproduce.
   C. maintain their environments.
   D. undergo new mutations.

   (9.3, B)

17. Natural selection acts on:

   A. chromosomes.
   B. gene pairs.
   C. individual genes.
   D. organisms.

   (9.3, D)

18. The life process of greatest importance to how evolution may occur is:

   A. homeostasis.
   B. locomotion.
   C. nutrition.
   D. reproduction.

   (9.3, D)

19. Darwin and Wallace discovered, independently of one another, the process of:

   A. adaptation to the environment.
   B. competition for survival.
   C. mutation from natural causes.
   D. natural selection by the environment.

   (9.3, D)

20. Darwin and Wallace independently hit on the idea that selection in nature could be very slow, but that it nevertheless favors as parents of the next generation those individuals whose:

   A. competition to survive and reproduce would not deprive others.
   B. food requirements were greatest and led to most competition.
   C. hereditary variations best adapted them to their environment.
   D. offspring would be most varied in their characteristics.

   (9.3, C)

21. At one time Charles Darwin bred pigeons. By selecting and crossbreeding the pigeons with traits he wished to study, he was able to produce in only a half dozen generations a new variety of birds that hardly resembled their recent ancestors. This contributed to his conviction that:

A. animal populations had diverse gene pools.
B. evolution had occurred in nature.
C. genes assorted independently in gametes.
D. mutations occurred in genes and chromosomes.

(9.3, AI, B)

22. What puzzled Darwin was not how he or other animal breeders made selections of parents for the next generation but how:

A. anything in nature could make selections of parents.
B. breeding could produce results at an observable rate.
C. plant and animal breeding had originated with people.
D. variation in animals expressed itself in breeding.

(9.3, A)

23. Darwin observed diverse flora and fauna in layers in the dense Brazilian rain forests. This suggested:

A. a struggle between organisms for the limited resources.
B. populations grow faster than their food supply.
C. that species are fixed.
D. that species are rapidly evolving.

(9.3, A)

24. Darwin's observations of mountains, volcanoes, and earthquakes in South America convinced him that:

A. different geological processes occur in different places.
B. great worldwide catastrophies have occurred in the past.
C. past geological processes are similar to today's processes that change the earth.
D. species are fixed and do not evolve.

(9.3, C)

25. Why is Charles Darwin correctly given more credit than Alfred Wallace for the theory of natural selection?

A. He published the theory first.
B. He was a better known scientist with more publications than Wallace.
C. His book *Origin of Species* presented convincing evidence supporting the theory.
D. His original ideas were different and more important than Wallace's.

(9.4, AI, C)

26. Mutations are considered a basis for evolution because they usually:

A. increase the variation among individuals.
B. occur in body cells instead of gametes.
C. produce little effect unless the environment changes.
D. survive in gene pools only if beneficial.

(9.5, A)

27. The mutation that has the least chance to survive in a population's gene pool is a:

A. codominant harmful allele.
B. dominant lethal allele.
C. recessive harmful allele.
D. recessive lethal allele.

(9.5, B)

28. A harmful allele whose frequency in a population probably will not be affected by natural selection is one that causes a:

A. degenerative disorder of older adults.
B. lethal condition in zygotes.
C. nondisjunction of chromosomes in gametes.
D. spontaneous abortion of embryos.

(9.5, A)

29. How do Mendel's findings affect Darwin's work?

A. Darwin used Mendel's theory to explain the source and inheritance of variations.
B. Darwin was unaware of or did not understand Mendel's work.
C. Mendel's work did not apply to Darwin's theory.
D. The scientific world immediately accepted Mendel's findings and used them to explain Darwin's theory.

(9.5, B)

30. In a dark-colored woods, natural selection acting on a prey species will cause the frequency of genes for dark color to:

A. decrease.
B. fluctuate.
C. increase.
D. remain the same.

(9.6, C)

31. Which is a principle underlying evolution?

A. all of the following
B. Gene frequencies in populations change.
C. Natural selection acts on genetic variations.
D. Only one or a few characteristics change at a time.

(9.6, A)

---

32. 1000 red and 1000 white ground beetles are placed on red clay and on white sand in cages containing insect-eating birds. Beetles are recaptured after 10 days. What is expected?

A. equal numbers of red and white beetles from both cages
B. more red beetles from both cages
C. more white beetles from both cages
D. more red beetles from the red clay cage and more white beetles from the white sand cage

(9.6, inv. 9.2, D)

33. Which best explains the results? The birds eat:

A. equal numbers of white and red beetles in both cages.
B. more red beetles in both cages.
C. more red beetles in the white sand cage and more white beetles in the red clay cage.
D. more white beetles in both cages.

(9.6, inv. 9.2, C)

Use the following information to answer the next three questions.

(9.6, AI)

A large number of dark and light forms of moths were captured and marked with paint on the under side for identification. 488 dark moths and 496 light moths were released. 14 surviving dark moths and 62 surviving light moths were later recaptured.

34. Which of the following would be the most reasonable hypothesis?

A. The moths were released in a forest with dark tree trunks.
B. Identical numbers of moths must be released.
C. The moths were released in a forest which had many light tree trunks.
D. The recaptured moths were too few in numbers to suggest a hypothesis.

(C)

35. The moths were marked with paint on the *under side* because:

   A. it was easier for the investigator to identify recaptured moths.
   B. when held for painting, it was easier to mark them in this way.
   C. paint on the upper side might have introduced another variable.
   D. paint will wear off the upper side of the moths more rapidly.

   (C)

36. This experiment on moth populations provides data on:

   A. the effect of environment on survival of moths showing variations.
   B. reproduction as a factor in maintaining populations of organisms.
   C. animals that feed on moths in a forest environment.
   D. ability of a species to exist in an unnatural environment.

   (A)

---

37. A major evolutionary event involves a change in a(n):

   A. community.
   B. ecosystem.
   C. individual.
   D. population.

   (9.6, D)

38. Which best illustrates the ability of living material to change from one form to another?

   A. A caterpillar pupates and changes into a butterfly.
   B. A wasp develops from a gall on an oak leaf.
   C. An egg hatches into a chicken.
   D. Bacteria are spontaneously generated from beef broth.

   (9.7, A)

39. When genes of poor adaptive value are linked to other genes of high adaptive value, natural selection may not affect the gene frequencies until:

   A. crossing over supplies new combinations.
   B. DNA replication begins in mitosis.
   C. nondisjunction of the chromosomes occurs.
   D. vegetative reproduction takes place.

   (9.8, A)

40. If the alleles of a gene are equally adaptive, their frequencies in the gene pool of a large population will probably:

   A. decrease.
   B. fluctuate.
   C. increase.
   D. remain the same.

   (9.8, D)

41. What is the source of genetic variability?

   A. all of the following
   B. crossing over (recombinations)
   C. mutations
   D. segregation and random recombination

   (9.8, A)

42. The isolation of a living population tends to produce change first in its:

   A. ecological niche.
   B. ecosystem.
   C. gene pool.
   D. habitat.

   (9.9, C)

43. Today, differences in the gene pools of two populations of the same species have been observed to occur especially when:

   A. both populations are about the same size.
   B. interbreeding occurs between the populations.
   C. one population is small and isolated from the other.
   D. overpopulation threatens both groups.

   (9.9, AI, C)

44. When a few individuals migrate from a population and start another population elsewhere, the chances are that their new gene pool does not reflect all the gene frequencies of the parent population. The first differences between the two populations will probably be those caused by:

A. climatic differences.
B. natural selection.
C. new mutations.
D. random genetic drift.

(9.9, D)

45. Which is *not* a way gene frequencies can change?

A. genetic drift
B. interbreeding within a population
C. migration of population into a new environment
D. mutation

(9.9, B)

Use the following key to answer the next eight items.

(9.9, AI)

KEY: A. Frequency of the dominant allele would increase but would not be 1.0 (100 percent).
B. Frequency of the recessive allele would increase but would not be 1.0 (100 percent).
C. No change would occur in allele frequencies.
D. Frequency of the dominant allele would be reduced to 0 in one generation.

What would happen to the allele frequency if:

____ 46. the recessive allele was lethal?

(A)

____ 47. individuals with the recessive trait were susceptible to a frequently fatal disease?

(A)

____ 48. individuals with the dominant trait were susceptible to a frequently fatal disease?

(B)

____ 49. individuals with the dominant trait produced fewer gametes?

(B)

____ 50. no selective factors of any kind were in operation in the population?

(C)

____ 51. the dominant allele was lethal?

(D)

____ 52. the population was of domestic animals for which only the recessive trait was prized by breeders?

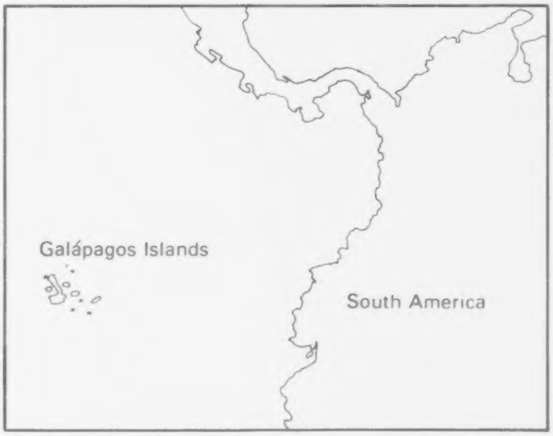
(B)

____ 53. all individuals with the dominant trait were slaughtered for market?

(D)

The next 12 items refer to the following map and to the information about the Galápagos finches.

(9.9–9.11, AI)



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The Galápagos Islands were pushed up from the sea as volcanoes more than a million years ago. The finches on the islands all differ from the finches that live on the mainland. From island to island the finches vary, although apart from size and beak shape they look almost identical. Finches are the only diverse group of land birds found on the islands. The other five land birds found are all varieties of a single species. Each species of finch differs greatly in beak shape from the others. Some have woodpecker-like beaks and feed on insects below the bark of trees. Others have beaks like sparrows and eat small seeds. Still others have parrot-like beaks and eat buds and fruits of trees. These finches are non-migratory and have a very short flying range. The nearest mainland is South America, some 600 miles east of the islands.

Use this key to evaluate the next statements.

KEY: A. The statement is in agreement with the theory of evolution and is supported by the data.

B. The statement is in agreement with the theory of evolution, but there is no information to support it.

C. The statement is not in agreement with the theory of evolution and is shown to be false by the data.

D. The statement is not in agreement with the theory of evolution, but the paragraph does not indicate that it is false.

____ 54. The different species of finches probably originated from a common ancestor:

(A)

____ 55. Fossil records, if they were available, would show no evidence of evolution of these birds:

(D)

____ 56. The different species of finches compete for the same food:

(C)

____ 57. Beak differentiation is one basis for considering the finches as separate species:

(A)

____ 58. Variations existed among individuals of the original species:

(B)

____ 59. The gene pools on the various islands were separated by a geographical barrier:

(A)

____ 60. The gene pool of the birds on one island was slightly different from the gene pool in the bird populations on another island:

(B)

____ 61. The various adaptations of these finches enhanced their chances of survival:

(A)

____ 62. The gene pool of the parrot-finch species is different from the gene pool of the woodpecker-finch species:

(A)

____ 63. Isolation was an important factor in the production of the various species of finches:

(A)

____ 64. The birds have become less diversified over the years, because some of them interbreed:

(D)

____ 65. The finches are adapted to a variety of environments:

(A)

66. What could happen when a large (drastic) genetic change occurs in an animal population?

A. all of the following
B. The variation will be lost because the organism will die or not breed.
C. The variation will rapidly increase in frequency.
D. The variation will remain in low frequency as the organism interbreeds with others.

(9.10, B)

67. The Hardy-Weinberg principle was not discovered in Darwin's time. Nevertheless, some evidence existed that plant and animal populations in nature tended to remain about the same in their variations from generation to generation unless:

A. generation time varied.
B. interbreeding occurred.
C. observations were interrupted.
D. selection was at work.

(inv. 9.3, D)

68. Salmon live together in the ocean as one population, but the *breeding* populations are different, because each salmon returns to the river where it was spawned for its own breeding. This type of isolation of subpopulations from one another is called:

A. behavioral isolation.
B. ecological isolation.
C. geographical isolation.
D. isolation in time.

(9.11, A)

69. Fossils similar to, but isolated from, living species may or may not be classified in the living species. Their form of isolation is:

A. behavioral isolation.
B. ecological isolation.
C. geographical isolation.
D. isolation in time.

(9.11, D)

70. Reproductive isolation takes many forms. When two varieties of a local plant species flower weeks apart, their isolation is caused by:

A. different ecosystems.
B. genetic differences.
C. geographical separation.
D. isolation in time.

(9.11, B)

The next four questions are based on the data below.

(9.11, AI)

A biologist made the following observations about two groups of salamanders.

KEY: The two groups:
A. have different coloration and arrangement of spots.
B. have a common ancestor based on the fossil record.
C. live in different, isolated habitats.
D. will interbreed and produce fertile offspring.

____ 71. Which observation provides the best evidence for the hypothesis that the salamanders are all of one species?

(D)

____ 72. Which observation suggests that the salamanders exist under conditions that might favor the evolution of separate species?

(C)

____ 73. Which observation includes a reference to an interpretation of data?

(B)

____ 74. Which observation could be changed by careful, selective interbreeding in the laboratory?

(A)

75. According to the theory of punctuated equilibrium, speciation:

- A. occurs rapidly, following periods of stability and extinction.
- B. occurs slowly after periods of widespread extinction.
- C. results by special creation following worldwide catastrophies.
- D. results from drastic (big) genetic changes.

(9.12, A)

76. How has Darwin's work on evolution held up over the years in the scientific world? His ideas have been:

- A. disproved completely.
- B. forgotten with the findings of modern research on population genetics.
- C. generally supported and form the foundation for our modern ideas.
- D. supported completely.

(9.14, C)

Chapter 10
Ordering Life in the Biosphere

1. A biologist who specializes in the classification of animals, plants, or microorganisms is called a:

   A. microbiologist.
   B. taxonomist.
   C. veterinarian.
   D. zoologist.

   (10.1, B)

2. Fertile offspring have been produced by cross-pollinating plants of not only different species, but different genera, and sometimes even different families. The same is not true of attempts to crossbreed widely different animals. This evidence indicates that the biological concept of a *species* is a:

   A. correct concept showing incorrect groupings in plant genera and families.
   B. human concept which plants do not fit as well as animals.
   C. law of nature that is not true in the laboratory.
   D. natural concept that operates only at the level of orders, classes, and phyla.

   (10.2, AI, B)

3. Two animals probably are of the same species if:

   A. they resemble each other.
   B. they can have offspring.
   C. their offspring can have offspring.
   D. they resemble their ancestors.

   (10.2, C)

4. Broccoli and cauliflower plants share the same scientific name, *Brassica oleracea*. This means that:

   A. broccoli will mature into cauliflower.
   B. classification of the plants is in error.
   C. different varieties of a plant species may exist.
   D. growing conditions determine type of yield.

   (10.2, AI, C)

5. Two animals in a zoo interbreed and produce fertile offspring. This observation indicates that the animals are members of the same:

   A. genus, but not necessarily species.
   B. order, but not necessarily family.
   C. phylum, but not necessarily class.
   D. species, but not necessarily population.

   (10.2, AI, A)

6. Two animals in their native surroundings interbreed and produce fertile offspring. This observation indicates that the animals are members of:

   A. different families.
   B. the same species.
   C. two related genera.
   D. two related species.

   (10.2, B)

7. Suppose some disease arose that killed all the dogs of the world except Great Danes and Pekingese. These two remaining kinds of dogs would probably be considered:

   A. the same species and genus.
   B. the same species, but two different genera.
   C. two different species, but the same genus.
   D. two different species and two different genera.

   (10.2, AI, C)

8. In a laboratory, Plants A, B, C, and D can be cross-pollinated in many pairings and will produce fertile offspring. Different flowering times prevent their cross-pollination in nature. One of the plants is a selectively bred or domestic garden plant; the other three are wild plants. How many species are probably represented?

A. one
B. one or two
C. two or three
D. three or four

(10.2, AI, D)

9. Which pair of organisms probably have more similarity between their DNA?

A. dogs and cats
B. fish and humans
C. oak trees and elephants
D. snakes and chickens

(10.3, A)

10. Taxonomists use different kinds of relationships to help classify organisms. However, for fossils the only evidence available is usually:

A. body structure.
B. habitat.
C. lifespan.
D. rock type.

(10.3, AI, A)

11. Modern classification places emphasis at all levels on relationships that indicate:

A. common ancestry.
B. common functions.
C. successful adaptations.
D. successful interbreeding.

(10.3, A)

12. Which of these animals is structurally most like humans?

A. bird
B. cat
C. chimpanzee
D. dog

(10.3, C)

13. The single most valuable characteristic used to classify organisms is:

A. behavior.
B. habitat.
C. metabolism.
D. structure.

(10.3, D)

14. Homology means similar:

A. function, based on environmental niche.
B. organisms, based on appearance.
C. structures, based on function.
D. structures, based on related ancestry.

(10.3, D)

15. Which of these categories of classification contains organisms that are most alike structurally?

A. class
B. family
C. genus
D. order

(10.3, C)

16. In which taxonomic category would the organisms be most similar?

A. family
B. genus
C. kingdom
D. order

(10.4, B)

17. Organisms in which taxonomic category would be more closely related?

    A. class
    B. family
    C. phylum
    D. species

    (10.4, D)

18. Classification systems, like most other scientific procedures, are:

    A. eventually proved correct.
    B. free of human error.
    C. revised after new evidence emerges.
    D. standard and never changed.

    (10.4, C)

19. In which of the following are the taxonomic categories arranged in increasing order (smallest to largest)?

    A. family, order, class, phylum
    B. class, order, genus, species
    C. genus, species, family, order
    D. order, family, class, phylum

    (10.4, A)

20. As you proceed from species to kingdom, the organisms grouped together share:

    A. different characteristics.
    B. fewer characteristics.
    C. less important characteristics.
    D. more characteristics.

    (10.4, B)

21. Which of the following categories includes the greatest number of different kinds of organisms?

    A. class
    B. family
    C. genus
    D. phylum

    (10.4, D)

22. The classification level for plants that corresponds to an animal phylum is called a:

    A. class.
    B. division.
    C. kingdom.
    D. order.

    (10.4, B)

23. A family includes closely related:

    A. classes.
    B. genera.
    C. orders.
    D. phyla.

    (10.4, B)

24. Which is an advantage for using the binomial system?

    A. all of the following
    B. All names are descriptive.
    C. All names are Latin words.
    D. An organism's name is the same in all languages.

    (10.5, D)

25. Taxonomists use binomial nomenclature to assign every species a name that consists of:

    A. brief classification data.
    B. common and scientific names.
    C. Greek-language terms.
    D. two descriptive words.

    (10.5, D)

26. One advantage of binomial nomenclature is that different species with the same common name are assigned:

    A. different scientific names.
    B. identical scientific names.
    C. new common names.
    D. separate taxonomic levels.

    (10.5, A)

27. A second advantage of binomial nomenclature is that the name assigned to a species is:

A. accepted without translation in every world language.
B. assigned to only one living and one extinct species.
C. eventually used as the common name of the living species.
D. evidence proving the existence of the species.

(10.5, A)

28. Without knowing the common names of *Poa pratensis*, *Poa annua*, and *Poa autumnalis*, you know that these organisms are in the same:

A. class.
B. family.
C. genus.
D. order.

(10.5, AI, C)

29. How do prokaryotes differ from eukaryotes? Eukaryotes:

A. have DNA, prokaryotes do not.
B. have membrane-bounded nuclei, prokaryotes do not.
C. lack mitochondria and lysosomes which prokaryotes have.
D. lack mitotic nuclear divisions which prokaryotes have.

(10.6, B)

30. Which is *not* a difference between eukaryotes and prokaryotes?

A. membrane-bounded nuclei
B. the composition of cell walls, when present
C. the present of mitochondria, Golgi, and lysosomes
D. the presence of ribosomes

(10.6, D)

31. In the 5-kingdom classification system, prokaryotes are grouped in the kingdom(s):

A. Monera.
B. Monera and Plantae.
C. Monera and Protista.
D. Protista.

(10.7, A)

32. In the 5-kingdom classification system, plants are separated from other eukaryotes mainly by:

A. method of reproduction.
B. nutritional pattern.
C. overall size.
D. the presence of an embryo.

(10.7, B)

33. In the 5-kingdom classification system, fungi are separated from other eukaryotes mainly by:

A. cell wall structure and development from spores.
B. nutrition pattern.
C. reproduction type (sexual/asexual).
D. size.

(10.7, A)

34. What do protists have in common? All:

A. are eukaryotes.
B. are microscopic.
C. have the same type of nutrition.
D. have similar life cycles.

(10.7, A)

35. Plants are distinguished from animals in many ways, including their production of a structural compound that animals do not produce. The name of this compound is:

A. cell protein.
B. cellulose.
C. pollen.
D. RNA.

(10.7, B)

36. Many taxonomists propose a separate kingdom for the fungi for the reason that these organisms have no:

A. cellular structure.
B. chlorophyll.
C. leaves, stems, or roots.
D. vascular tissue.

(10.7, B)

37. A new unicellular organism is found. It has cellulose cell walls, membrane-bounded organelles, chloroplasts containing chlorophyll and several chromosomes. It is most likely a(n):

A. animal.
B. fungus.
C. prokaryote.
D. protist.

(10.7, AI, D)

38. Why do classification systems change?

A. all of the following
B. Distinct boundaries between categories are rigid but change.
C. Our knowledge about organisms is no good.
D. They depend upon the purposes of the classifier.

(10.8, D)

39. Two classifications of all the different species in a lake are made. In one system the organisms are classified by food chains. In the other they are classified by phylum, class, order, and so on. Which of the following statements is most reasonable?

A. A single system should be agreed upon.
B. Both systems are useful in different investigations.
C. One system is more accurate than the other.
D. One system is biologically useful; the other is not.

(10.8, AI, B)

40. If evolutionary theory that organisms arise from a common ancestor is correct, then:

A. older fossils should be more complicated.
B. older fossils will have smaller populations.
C. older sedimentary rocks should have fewer kinds of fossils.
D. older sedimentary rocks should have more kinds of fossils.

(10.9, AI, C)

41. Some biologists classify algae with plants because they have:

A. chlorophyll along with other pigments.
B. seedlike structures in their single cells.
C. surface blooms in their water habitat.
D. vascular tissue in their large seaweeds.

(10.9, A)

42. Producers, consumers, parasites, predators, and decomposers are all included among the small organisms that are classified as:

A. algae.
B. fungi.
C. protists.
D. viruses.

(10.9, C)

43. Some animals are difficult to classify because they resemble one order or class in some ways and another in other ways. This suggests that the animals and the two orders or classes they lie between are:

A. accidentally related by interbreeding.
B. chance examples of the same structures.
C. changed descendants of a common ancestor.
D. incorrectly identified for classification.

(10.9, AI, C)

44. The oldest fossils known today are dated at:

A. 3.5 thousand years ago.
B. 3.5 hundred thousand years ago.
C. 3.5 million years ago.
D. 3.5 billion years ago.

(10.10, D)

45. In laboratory experiments, materials like many of those found in organisms can be produced from gases thought to have been present in the earth's early atmosphere. An energy source in these experiments, high-voltage sparks or electric discharges, is used to represent:

A. atmospheric lightning.
B. high air temperatures.
C. solar flares.
D. ultraviolet radiation.

(10.11, A)

46. In the experiments in item 45, the gases used, based on geological evidence, were:

A. CH_4, N_2, O_2 and H_2
B. CH_4, NH_3, H_2O and H_2
C. CO_2, H_2O, NH_3 and O_2
D. CO_2, N_2, H_2O and H_2

(10.11, B)

47. The hypothesis for how life began in the earth's waters is based on accumulating evidence that:

A. atmospheric gases made up a thin "soup."
B. continents formed a single land mass.
C. ocean waters covered the entire planet.
D. organic compounds occurred in nature.

(10.11, D)

48. The first cells were probably:

A. autotrophs
B. coacervates.
C. heterotrophs.
D. microspheres.

(10.12, C)

49. The formation of coacervates:

A. shows how amoeba-like organisms first formed.
B. might have been a way in which protein-like substances were concentrated.
C. shows that under natural conditions simple molecules may sometimes combine to form complex molecules.
D. shows living things are composed only of protein.

(10.12, B)

50. The idea that the first organisms on earth were unable to produce their own food is part of:

A. the heterotroph hypothesis.
B. the autotroph hypothesis.
C. biogenesis.
D. spontaneous generation.

(10.12, A)

51. What did the evolution of autotrophs result in?

A. all of the following
B. Free O_2 accumulated in the earth's atmosphere.
C. It enabled the evolution of heterotrophs.
D. Ozone was depleted and untraviolet light was filtered out.

(10.13, B)

Chapter 11
Prokaryotes and Viruses

1. Which best describes prokaryotes?

   A. Most are beneficial.
   B. Most are harmful.
   C. They are complex structurally and functionally.
   D. They are evolutionarily recent and quite delicate.

   (11.1, A)

2. Why are bacteria important?

   A. all of the following
   B. They are all parasitic and pathogenic.
   C. They have a simple structure and metabolism.
   D. They play an important role in all food webs.

   (11.1, D)

For the next eight items use the following information and chart.

(inv. 11.1, AI)

A pure strain of Bacteria X was prepared for culturing. One-third of the bacterial population was mixed with each of three media. Each medium was then poured into one of the three different petri dishes. The following data were obtained.

Petri dish number	Medium	Colonies in dish after 36 hours
I	Agar and carbohydrates	200
II	Agar, carbohydrates, and vitamin B	2,240
III	Agar and vitamin B	0

Use the following key to identify the petri dishes that support the statements in the next five items.

KEY: A. I and II
B. II and III
C. neither pair

____ 3. Carbohydrates are necessary for growth of Bacteria X:

(B)

____ 4. Agar is necessary for growth of Bacteria X:

(C)

____ 5. Vitamin B is not necessary for growth of Bacteria X:

(A)

____ 6. Carbohydrates are used as an energy source by Bacteria X:

(B)

____ 7. Vitamin B is necessary for maximum growth of Bacteria X:

(A)

8. Which of the following is an experimental variable in the design of this investigation?

   A. Bacteria X
   B. agar
   C. carbohydrates
   D. number of colonies

   (C)

9. Which of the following is also an experimental variable in the design of this investigation?

   A. number of dishes
   B. size of colonies
   C. time
   D. vitamin B

   (D)

10. The results of this investigation indicate that Bacteria X can:

A. make its own food using vitamin B.
B. obtain food energy from either carbohydrates or agar.
C. survive on food without vitamins.
D. use nitrogen from air to make nitrogen compounds.

(C)

---

11. To obtain a pure culture starting with a mixed culture plate, one should take:

A. samples of nutrient where no colonies appear.
B. only one or two loopfuls of microorganisms.
C. microorganisms from a single colony.
D. one colony and sterilize it.

(inv. 11.1 C)

12. One ml of a pond-water sample is diluted by the addition of 99 ml of sterile water. If, under controlled conditions, 1 ml of the diluted pond-water sample produces three colonies of bacteria, about how many bacteria should be present in 10 ml of the *undiluted* pond water?

A. fewer than 50
B. several hundred
C. several thousand
D. several million

(inv. 11.1, C)

13. What does a bacterial colony on a culture plate represent?

A. a population descended from one or two bacteria
B. a migration of bacteria into a cluster
C. a single bacterium
D. a community of related species

(inv. 11.1, A)

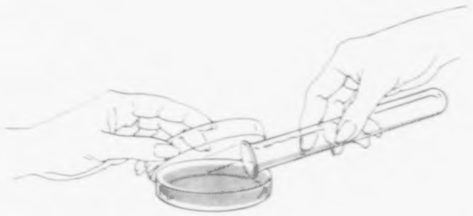
14. A certain species of bacteria reproduces every half hour under suitable conditions. Starting with two bacteria, how long would it take to obtain a population of approximately 1000 individuals?

A. 2½ hours
B. 4½ hours
C. 6½ hours
D. 8½ hours

(inv. 11.1, AI, B)

The next three items are based on the following drawing:

(inv. 11.1, AI)



15. Pouring a culture plate as shown is intended primarily to reduce:

A. glass breakage.
B. exposure to burns.
C. exposure to airborne microorganisms.
D. splashing of the nutrient medium.

(C)

16. The cover is placed over the bottom in order to:

A. grow colonies of microorganisms.
B. prove the laboratory free of bacteria.
C. store the nutrient medium until needed.
D. streak suspected laboratory surfaces with nutrient.

(A)

17. The gradual appearance of the investigator's initials on the plate after exposure would confirm:
    A. proper identification and labeling.
    B. the streaking pattern used to expose the plate.
    C. a chance laboratory occurrence.
    D. spontaneous generation of microorganisms.

    (B)

---

18. Which best describes archaebacteria? They:
    A. appeared on earth only recently.
    B. are fundamentally different from all other organisms.
    C. are very similar to eubacteria.
    D. have DNA and RNA similar to all other organisms.

    (11.2, B)

19. Archaebacteria differ from eubacteria in:
    A. all of the following
    B. the chemical composition of their cell walls.
    C. the number of different kinds of membrane-bounded organelles.
    D. their possession of a definite nucleus.

    (11.2, B)

20. Archaebacteria differ from eubacteria in:
    A. all of the following
    B. the chemical composition of their cell walls.
    C. the lipids in their membranes.
    D. their ribosomal and transfer RNA.

    (11.2, A)

21. Which is true of methanogens?
    A. all of the following
    B. They are found in sewage treatment plants.
    C. They are killed by oxygen.
    D. They produce methane.

    (11.3, A)

22. Which best describes halophiles? They can grow in a(n):
    A. cool dry environment.
    B. hot acidic environment.
    C. oxygen-free environment.
    D. salty environment.

    (11.3, D)

23. Which of the following groups of prokaryotes are considered to be archaebacteria?
    A. all of the following
    B. the extreme halophiles
    C. the methanogens
    D. the thermoacidophiles

    (11.3, A)

24. Which would you find living in hot sulfur springs and smoldering piles of coal?
    A. cyanobacteria
    B. halophiles
    C. methanogens
    D. thermoacidophiles

    (11.3, D)

25. Which group of microorganisms could play an important role in solving our garbage, sewage and agricultural waste problem?
    A. cyanobacteria
    B. halophiles
    C. methanogens
    D. thermoacidophiles

    (11.3, C)

26. Which are major producers with a physiology similar to algae and plants?
    A. cyanobacteria
    B. halophiles
    C. methanogens
    D. soil bacteria

    (11.4, A)

27. What do cyanobacteria have in common with other eubacteria?

A. all of the following
B. They are anaerobic.
C. They have a chloroplast with chlorophyll.
D. They lack a membrane-bounded nucleus.

(11.4, D)

28. Animals get their nitrogen from:

A. animal and plant foods.
B. atmospheric ammonia.
C. atmospheric nitrogen gas.
D. nitrates in water or soil.

(11.5, A)

The next 10 items refer to the nitrogen cycle. For the first 9 of these 10 items, select the letter of the term from the key that best matches each numbered item.

(11.5, AI)

KEY: A. ammonia (NH_3) or ammonium (NH_4^+)
B. atmospheric nitrogen (N_2)
C. soil nitrates (NO_3)

____ 29. the most abundant nitrogen supply:

(B)

____ 30. the nitrogen supply usable by fewest producers:

(B)

____ 31. the nitrogen supply used by most producers:

(C)

____ 32. the source of nitrogen in nitrogen-fixation by lightning:

(B)

____ 33. the kind of nitrogen compound produced by lightning discharges:

(A)

____ 34. the source of nitrogen in nitrogen-fixation by bacteria:

(B)

____ 35. the kind of nitrogen compound produced by nitrogen-fixing bacteria:

(A)

____ 36. the nitrogen supply increased by crop plants such as alfalfa and clover:

(A)

____ 37. the kind of nitrogen compound produced by nitrifying bacteria:

(C)

38. In the nitrogen cycle, the organisms that take nitrogen from the air and fix it in compounds plants can use are:

A. algae.
B. bacteria.
C. fungi.
D. legumes.

(11.5, B)

The next four items use the following groups of bacteria as responses. Any one group may be used more than once or not at all. There is only one response for each item (statement).

(11.5)

KEY: A. decomposing bacteria
B. denitrifying bacteria
C. nitrifying bacteria
D. nitrogen-fixing bacteria

____ 39. convert atmospheric nitrogen to ammonia:

(D)

____ 40. change ammonium ions to nitrates:

(C)

____ 41. break down nitrogen containing compounds and release ammonium ions:

(A)

____ 42. change nitrates to nitrogen gas:

(B)

---

43. If you were an investigator of crop plants, you probably should consider experimenting to develop new kinds of food crops that could:

A. grow without nitrogen.
B. obtain nitrates from animal manure.
C. survive lightning discharges.
D. use atmospheric nitrogen.

(11.5, AI, D)

44. Which of these plants are hosts to organisms that put nitrogen compounds into the soil?

A. carrots and corn
B. onions and potatoes
C. peas and soybeans
D. weeds and wild flowers

(11.5, C)

45. The nitrogen cycle is vital because animals and most green plants cannot use:

A. gaseous nitrogen.
B. nitrates.
C. nitrogen in any form.
D. organic nitrogen compounds.

(11.5, A)

46. The first evidence that diseases can be caused by microorganisms came from the study of:

A. asthma.
B. bacteria on teeth.
C. potato blight.
D. scurvy.

(11.6, C)

The next seven items relate to investigating the causes of different diseases.

(11.7, AI)

47. One should tentatively rule out an environmental cause for a disease that occurs mainly in people in certain:

A. geographical areas.
B. families.
C. months of each year.
D. occupations.

(B)

48. One should tentatively rule out a hereditary cause for a disease that occurs mainly in people of certain:

A. families.
B. nationalities.
C. occupations.
D. racial groups.

(C)

49. One should tentatively rule out a dietary cause for a disease that occurs mainly in people of certain:

A. blood types.
B. body weights.
C. impoverished areas.
D. overpopulated countries.

(A)

50. One should tentatively rule out a pathogen as the cause for a disease that occurs mainly in people living in certain:

A. climates.
B. countries.
C. high altitudes.
D. impoverished areas.

(C)

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51. One step in confirming a pathogen as a cause of human disease is finding it in each:

A. afflicted community.
B. air sample.
C. disease victim.
D. food tested.

(C)

52. Another step, if possible, in confirming a pathogen as a cause of human disease is eliminating the source of the pathogen and subsequently observing:

A. elimination of the disease.
B. increased immunity.
C. recovery of victims.
D. stricter food regulations.

(A)

53. Another step in confirming a pathogen as a cause of human disease is culturing it successfully on samples of healthy tissues from:

A. fresh foods.
B. immune species.
C. laboratory animals.
D. various people.

(D)

The next ten items list human disorders and diseases. Use the key to indicate the most effective *current* method of control.

(11.7, AI)

KEY: A. better diet and living habits
B. destruction of vector's breeding habitat
C. immunization by inoculation
D. surgery

____ 54. circulatory diseases:

(A)

____ 55. tetanus:

(C)

____ 56. malaria:

(B)

____ 57. measles:

(C)

____ 58 cancer:

(D)

____ 59. typhoid fever:

(C)

____ 60. heart diseases:

(A)

____ 61. appendicitis:

(D)

____ 62. malnutrition:

(A)

____ 63. influenza:

(C)

---

64. The term *environmental disease* was almost unknown some years ago, although allergies to pollen and other agents have been long known. The chief new cause of environmental diseases has proved to be:

A. chemical pesticides and pollutants.
B. growth of dependence on medicines.
C. new varieties of plant pollens.
D. space crowding in cities.

(11.7, A)

65. The chief causes of death in the United States have shifted in this century from:

A. contagious to vector diseases.
B. deficiency to contagious diseases.
C. degenerative to environmental diseases.
D. infectious to degenerative diseases.

(11.7, D)

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66. What kind of disease is a respiratory disorder caused by pollutants?

A. contagious disease
B. degenerative disease
C. environmental disease
D. vector disease

(11.7, C)

67. Pathogens are transmitted from host to host by:

A. all of the following
B. air or water.
C. direct contact.
D. vector.

(11.8, A)

68. Certain fungi and bacteria produce substances that kill or inhibit growth of competing microorganisms. These substances are called:

A. abiotics.
B. anaerobics.
C. antibiotics.
D. antibodies.

(11.8, C)

69. Pathogens causing contagious diseases are spread from:

A. host to host.
B. pathogen to pathogen.
C. species to species.
D. vector to victim.

(11.8, A)

70. A pathogen or pathogenic organism is defined as one that:

A. acts on antibiotics.
B. causes decay.
C. causes disease.
D. eats nonliving food.

(11.8, C)

71. For a disease to be infectious its pathogen must be:

A. carried by a vector.
B. soluble in the plasma of the host's bloodstream.
C. transmitted from an affected host to a healthy one.
D. unaffected by antibodies.

(11.8, C)

72. What three causes of disease would probably first be investigated for a disease that afflicts family members but none of the neighbors?

A. contagious, degenerative, and vector-borne
B. dietary deficiency, environmental, and hereditary
C. degenerative, infectious, and venereal
D. environmental, vector-borne, and venereal

(11.8, AI, B)

73. A vector for an infectious disease may be an alternate:

A. host species.
B. human victim.
C. pathogenic species.
D. set of symptoms.

(11.8, A)

74. Two well-known agents of environmental disease are:

A. bacteria and fungi.
B. foods and garbage.
C. pets and fleas.
D. pollen and pollutants.

(11.8, D)

75. An organism that causes disease in another organism is called a:

A. host.
B. pathogen.
C. predator.
D. vector.

(11.8, B)

76. For an organism to be considered a pathogen, it must cause:

A. death.
B. decomposition.
C. discomfort.
D. disease.

(11.8, D)

77. A vector is an organism that:

A. causes a disease in a host.
B. is affected by a pathogen, causing a disease.
C. prevents a pathogen from entering a host.
D. transmits a pathogen from one host to another.

(11.8, D)

78. Malaria is a disease caused by a pathogen transmitted by:

A. a vector.
B. air.
C. contaminated water.
D. infected food.

(11.8, A)

For the next five items use the following key.

(11.8)

KEY: A. host
B. pathogen
C. symptom
D. vector

____ 79. any disease-producing organism:

(B)

____ 80. a sign of illness:

(C)

____ 81. a nonhuman species that carries human disease organisms:

(D)

____ 82. any organism from which parasites obtain their food:

(A)

____ 83. a human victim of a disease organism:

(A)

---

84. Microorganisms that cause diseases of other organisms are called:

A. hosts.
B. pathogens.
C. predators.
D. vectors.

(11.8, B)

85. The term *virulence* refers to:

A. the ability of a pathogen to cause a disease.
B. the number of pathogens in a host.
C. a period between exposure and illness.
D. a virus as the cause of a disease.

(11.8, A)

86. Which cause human diseases?

A. all of the following
B. deficiencies in the diet
C. environmental stress or substances
D. inherited disorders

(11.8, A)

87. The virulence of a pathogen and the resistance of the host species represent:

A. a competition for food.
B. an ecological balance.
C. a mutualistic relationship.
D. the vector of a disease.

(11.8, B)

The next five items are based on this diagram of a culture plate. A, B, C, and D are disks of filter paper, each soaked with a different antibiotic.

(inv. 11.2, AI)

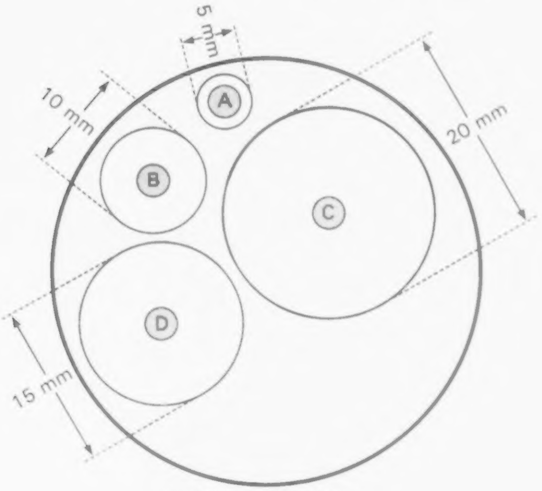


PLATE INOCULATED
WITH BACTERIA
ISOLATED FROM
SICK PERSON

____ 88. Which antibiotic—A, B, C, or D—appears least effective against these bacteria?

(A)

____ 89. If this culture plate represented your only information, which antibiotic would you prescribe to eliminate the bacteria?

(C)

____ 90. Suppose you investigate the four antibiotics and discover that disk B is soaked in a concentration only one tenth as strong as the concentrations of the other three antibiotics. Which antibiotic now appears most effective against the bacteria?

(B)

91. Name the factor that was probably least important to the results of this type of test.

A. the numbers of bacteria on the culture plate
B. the expiration date on each bottle of antibiotic
C. the maintenance of the plate at human body temperature
D. the length of time required for the antibiotics to act

(A)

92. Whether further tests should be made before prescribing an antibiotic depends most upon the age and condition of the:

A. antibiotics in the samples.
B. bacterial colonies distributed on the plate.
C. nutrient medium on the plate.
D. patient infected by the bacteria.

(D)

---

93. The ability of a host to cope with a pathogen is called its:

A. pathogenicity.
B. resistance.
C. symptoms.
D. virulence.

(11.9, B)

94. Which affects the virulence of a pathogen?

A. all of the following
B. how easily it can get into the host
C. its ability to grow and spread rapidly
D. the amount and kind of toxins produced

(11.9, A)

95. You "catch" a disease. A year later, most students in your class get the same disease, but you do not get it again. Which principle about resistance is best illustrated?

A. Large numbers of pathogens can overwhelm the immune system.
B. Pathogens must be transported from host to host.
C. Poor nourishment lowers resistance.
D. The immune system has a memory.

(11.9, AI, D)

96. You get influenza. A month afterwards, everyone around you gets the flu but you do not. The next month another flu outbreak occurs and you get the disease. Which best explains why you got the flu again?

A. The antibodies you produced mutated and would not interact with the flu virus.
B. The virus causing the flu mutated and would not interact with your antibodies.
C. Your artificial immunity wore out.
D. Your immune system lacked a memory.

(11.9, AI, B)

97. Which is *not* true of the immune system?

A. Antibodies are specific for certain antigens on the pathogens that induced their formation.
B. Antibodies may be produced even though the pathogens do not cause disease symptoms.
C. It has a "memory."
D. It is only inherited and it gives you resistance against certain pathogens.

(11.9, D)

98. Natural or acquired immunity to a disease usually is not related to:

A. antibodies.
B. antibiotics.
C. heredity.
D. inoculations.

(11.9, B)

99. Artificial immunity occurs when you are inoculated with:

A. antibodies produced by an animal innoculated with the pathogen.
B. antigens produced by an animal innoculated with the pathogen.
C. dead pathogens.
D. live pathogens.

(11.9, A)

100. Which is *not* true of immunity? It:

A. involves antibodies.
B. is effective against all different pathogens.
C. may be acquired by contact with pathogens.
D. may be inherited.

(11.9, B)

101. Which is involved in virulence of a pathogen?

A. antibodies produced by the pathogen
B. antigens produced by the host
C. production of toxins by the pathogen
D. the host's resistance to antibiotics

(11.9, C)

For the next five items select from the key the letter of the indicated term.

(11.9)

KEY: A. artificial immunity
B. inherited immunity
C. natural immunity
D. vaccination

____ 102. the reason some microorganisms are not known to be virulent to people:

(B)

____ 103. immunity acquired by having a disease and producing antibodies against reinfection by the same pathogen:

(C)

____ 104. immunity acquired by injection of dead or weakened pathogens to stimulate production of antibodies:

(A)

____ 105. the first immunization procedure to be discovered, used against smallpox:

(D)

____ 106. immunity acquired by injection of a pathogen's toxin to stimulate production of antibodies:

(A)

---

107. In the development of natural immunity in a person, antibodies are produced:

A. by antibiotics.
B. in another animal.
C. by laboratory methods.
D. in that person.

(11.9, D)

108. Tetanus is caused by bacteria that:

A. are carried by a vector.
B. are transmitted by sexual contact.
C. enter a wound and produce a toxin.
D. enter the body with food or water and spread rapidly.

(11.9, C)

109. How can you prevent disease from spoiling food?

A. any of the following
B. Add chemicals to stop or slow down growth of microbes.
C. Add salt or sugar to food to prevent spoiling.
D. Heat the food to kill any organisms present.

(11.10, A)

110. Which of these home products was made for protection against microorganisms?

A. blender
B. electric iron
C. freezer
D. toaster

(11.10, C)

111. Botulism results from:

A. bacteria transmitted by air.
B. protozoa transmitted by mosquitoes.
C. toxins produced by bacteria in food.
D. viruses transmitted by contaminated water.

(11.10, C)

112. A refrigerator retards food spoilage by:

A. keeping out bacteria.
B. killing bacteria.
C. neutralizing bacterial toxins.
D. slowing down bacterial reproduction.

(11.10, D)

113. Almost all pathogenic organisms on agar plates could be killed by:

A. boiling the plates for 10 minutes.
B. exposing the plates to sunlight.
C. pouring hot water on the agar.
D. pressure cooking the plates 15 minutes.

(11.10, D)

114. Why might viruses be considered living?

A. all of the following
B. They have cellular structure with organelles.
C. They have nucleic acids and can reproduce inside host cells.
D. They have metabolism and can feed and grow.

(11.11, C)

115. Bacteria share with viruses the characteristic of being:

A. crystallized when inactive.
B. invisible to the naked eye.
C. invisible under the compound microscope.
D. unable to reproduce outside a host organism.

(11.11, B)

The next ten items apply to viruses, and specifically to the evidence for and against considering them living. Answer each item using a letter from the key.

(11.11, AI)

KEY: A. evidence for considering viruses as living
B. evidence against considering viruses as living
C. hypothesis, not necessarily supported by evidence
D. evidence neither for nor against considering viruses as living

____ 116. Many viruses cause diseases of plants and animals:

(D)

____ 117. Virus-caused diseases often are contagious; the viruses reproduce and spread to infect healthy individuals:

(A)

____ 118. Viruses cannot be seen with a compound microscope:

(D)

____ 119. Viruses can be crystallized and stored on a laboratory shelf like salt:

(B)

____ 120. The electron microscope shows viruses to be of many different shapes and sizes:

(D)

____ 121. Viruses have not been grown on any kind of laboratory nutrient medium:

(B)

____ 122. Viruses are made up of compounds found in organisms but not in the abiotic environment:

(A)

____ 123. Viruses can reproduce inside living organisms only:

(B)

____ 124. Viruses may be descendants of organisms that somehow lost most of their biological features:

(C)

____ 125. Viruses may demonstrate incomplete development toward the living state:

(C)

The following items use the following as responses.

KEY: A. cyanobacteria
B. prions
C. viroids
D. viruses

____ 126. made up of only protein; cause diseases such as scrapie and kuru:

(11.12, B)

____ 127. pieces of naked RNA; cause certain plant diseases:

(11.12, C)

____ 128. formerly called blue-green algae:

(11.4, A)

____ 129. made up of protein and nucleic acids; some (called bacteriophages) infect bacteria:

(11.11, D)

Chapter 12
Eukaryotes: Protists and Fungi

1. Which of the following groups of organisms includes producers, consumers, decomposers, parasites, predators, and prey?
   - A. animals
   - B. bacteria
   - C. fungi
   - D. protists

   (12.1, D)

2. Eukaryotes are considered more advanced than prokaryotes because:
   - A. all of the following
   - B. eukaryotes are all multicellular.
   - C. eukaryotes are larger and more complex.
   - D. eukaryotes are more numerous.

   (12.1, C)

3. Which is evidence that mitochondria arose as a mutualistic relationship between small and large prokaryotes?
   - A. all of the following
   - B. Certain ameoba have aerobic bacteria living in them instead of mitochondria.
   - C. Mitochondria are produced only by division of other mitochondria.
   - D. Mitochondria have prokaryote-like DNA and ribosomes.

   (12.2, A)

4. The discovery of algae cells living inside digestive cells lining the gut of hydras supports the hypothesis that:
   - A. hydras are actually algae rather than animals.
   - B. hydras are actually protists rather than animals.
   - C. mitochondria and chloroplasts originated as free living prokaryotes.
   - D. symbiosis is a form of parasitism.

   (12.2, C)

5. Which is a characteristic of protists?
   - A. all of the following
   - B. All are heterotrophs and either predators or parasites.
   - C. All are unicellular with organelles.
   - D. All carry out aerobic respiration in mitochondria.

   (12.3, D)

6. The protist kingdom consists mainly of eukaryotic organisms that are:
   - A. closely related to one another.
   - B. parasitic on one another.
   - C. not plants, animals, or fungi.
   - D. disease-causing to plants and animals.

   (12.3, C)

7. All protists are:
   - A. autotrophic.
   - B. eukaryotic.
   - C. heterotrophic.
   - D. parasitic.

   (12.3, B)

8. Slime molds (Myxomycota) are characterized by:
   - A. being parasites of both plants and animals.
   - B. being producers with chloroplasts in their cells.
   - C. having a multinucleate plasmodium.
   - D. having a simple life cycle consisting of single cells.

   (12.4, C)

If all organisms had to be classified as either plants or animals, cellular slime molds would present a problem. Use the key to explain the situations listed in the next six items.

(12.4, AI)

KEY: a characteristic of cellular slime molds that is:

A. animallike
B. plantlike
C. unlike animals or plants

____ 9. During part of their life cycle the cellular slime molds are single flagellate units that can move about:

(A)

____ 10. Later the individuals lose their flagella and become amoebalike, but can still move about:

(A)

____ 11. Still later the amoebalike units come together and form a large mass that looks and moves like a slug:

(A)

____ 12. Upright stalks appear, and these develop structures in which spores are produced:

(B)

____ 13. The spores develop into flagellate units:

(A)

____ 14. During the amoebalike period the individuals ingest solid foods such as bacteria and oatmeal:

(A)

The next 15 items relate to a series of investigations with slime molds. During a large part of the life cycle of a slime mold, *Dictyostelium*, the mold forms separate units that look like amoebas. Each unit produces new individuals that feed on bacteria. At intervals, as many as 500,000 of these amoebalike individuals come together and form a colony. This colony acts as a single organism and resembles a slug.

(12.4, AI)

Question: What causes the amoebalike units to come together?

HYPOTHESES:

A. They become sticky and form into colonies wherever they accidentally bump into one another.
B. They give off some kind of ray that attracts the others.
C. They give off some chemical that attracts the others.
D. They produce an electric field that affects others in the field.

Investigation 1. A small section of a developing colony was placed on one side of a piece of cellophane that allowed only liquid to pass through. Some of the amoebalike units were placed on the other side. The units all headed for the spot opposite the mass of cells on the other side of the cellophane. They formed a colony there.

____ 15. Which hypothesis can be eliminated as a result of this investigation?

(A)

Investigation 2. The same investigation was performed, but a very thin sheet of metal was used instead of the cellophane. The units formed a colony, but it was not located opposite the colony on the other side.

____ 16. Which hypothesis probably can be eliminated as a result of this investigation?

(D)

Investigation 3. The experiment was repeated, but a thin glass plate was used instead of cellophane or metal. The glass plate was suspended in water. The units all moved around the edge of the glass and became attached to the colony on the other side.

____ 17. Which hypothesis probably can be eliminated on the basis of this investigation?

(B)

____ 18. Which appears to be the best of the hypotheses presented?

(C)

Investigation 4. Liquid was taken from near a colony of units. It was placed immediately in a small spot on agar that contained individual units. For a moment the individuals swarmed toward the spot, and then they stopped.

____ 19. Which hypothesis tends to be supported by this investigation?

(C)

20. What new question is raised by Investigation 4?

A. What causes the single units to come together in colonies?
B. What causes the units to stop moving toward the drop of liquid?
C. Do all types of slime molds form colonies?
D. What are slime molds?

(B)

Investigation 5. Liquid, collected near the colony, was passed immediately through a cellophane bag. (Only small molecules can pass through cellophane.) When a drop of this liquid was placed on agar containing individual units, the units moved toward the drop without stopping. A few drops of the liquid that remained in the bag were added to the liquid that had passed through it. There appeared to be a mutual attraction between the units and the colony for a moment. Then the attraction stopped.

21. How many kinds of substances does the colony appear to produce?

A. 1
B. 2
C. 3
D. 4

(B)

22. Which of the following assumptions is unnecessary in interpreting the results of the investigation?

A. Cellophane does not affect the nature of the attracting substance.
B. The experiment does not affect the chemical activity of the slime molds.
C. Other slime molds produce the same substance or substances as *Dictyostelium.*
D. Water itself does not contain an attractant for slime molds.

(C)

For the next seven items use the following key to evaluate the statements that follow it.

KEY: A. restatement of observation
B. interpretation justified by the results
C. interpretation contrary to the results
D. interpretation based on insufficient evidence

____ 23. The colony produces a substance that attracts the individual units:

(B)

____ 24. The units become accustomed to the stimulus and stop reacting to it:

(C)

____ 25. The colony produces a substance that destroys the attracting substance:

(B)

____ 26. Units move toward a drop of liquid that was passed through cellophane:

(A)

____ 27. The attracting substance has a small molecular size:

(B)

____ 28. The attracting substance can be destroyed by an acid:

(D)

____ 29. The attracting substance can be broken down in the presence of certain other substances:

(B)

30. Among flagellates, the same individual in some species may be both:

A. aquatic and terrestrial.
B. a micro- and macroorganism.
C. a producer and a consumer.
D. parasitic and free-living.

(12.5, C)

31. Amoebas move by using:

A. cilia.
B. flagella.
C. pseudopods.
D. water currents.

(12.6, C)

32. Species that carry on photosynthesis have not been found among the:

A. algae.
B. cyanobacteria.
C. flagellates.
D. sporozoa.

(12.7, D)

Use the following groups of protists as responses for the next six questions. Any one group (response) may be used more than once or not at all.

(12.5–12.8)

KEY: A. ciliates
B. flagellates
C. sarcodines
D. sporozoans

____ 33. Includes amoebas; they move by pseudopods:

(C)

____ 34. All are parasites that produce spores; they lack any means of locomotion:

(D)

____ 35. Uninucleate, unicellular organisms that move by long whip-like organelles (appendages):

(B)

____ 36. Includes the organisms that cause "red tides," human diseases such as sleeping sickness; found in termite guts:

(B)

____ 37. Some produce calcium carbonate shells, which accumulated to form rocks like those found in the white cliffs of Dover:

(C)

____ 38. Move by many short whip-like extensions (organelles); have definite semi-rigid shapes and two kinds of nuclei:

(A)

39. In a saltwater environment, the contractile vacuole of *Amoeba* would:

A. be absent.
B. get rid of excess water.
C. get rid of excess salts.
D. serve for locomotion.

(inv. 12.1, AI, A)

40. Asexual reproduction in *Paramecium* usually results in:

A. death of one cell.
B. cells of the same size as the parent.
C. two identical offspring.
D. two offspring with very different characteristics.

(inv. 12.1, C)

41. In *Paramecium*, digestion takes place in the:
   - A. surrounding medium followed by absorption.
   - B. food vacuoles moving through the cytoplasm.
   - C. contractile vacuole as it expands and contracts.
   - D. macronucleus, which controls metabolism and energy transfer.

(inv. 12.1, B)

42. In pond water, protozoa excrete:
   - A. water faster than they take it in.
   - B. salt faster than they absorb water.
   - C. water slower than they take it in.
   - D. water about as fast as they take it in.

(inv. 12.1, D)

43. Suppose the contractile vacuoles of *Paramecium* were removed. Which of the following would happen?
   - A. They could not eat.
   - B. They could not move.
   - C. They would burst.
   - D. They would divide in two.

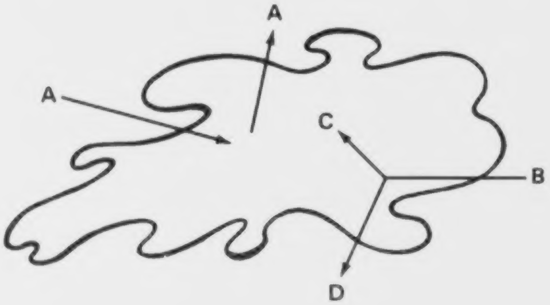
(inv. 12.1, C)

44. Which of the following would you expect to result if the cilia of the oral groove of *Paramecium* were removed?
   - A. The quantity of food particles taken in would be reduced.
   - B. Action of the contractile vacuoles would be increased.
   - C. Elimination of wastes would be increased.
   - D. Reproduction would occur almost immediately but would be abnormal.

(inv. 12.1, AI, A)

The next five items refer to the outline of *Amoeba*. The letters represent various substances that pass into and out of the cell in fresh water.

(inv. 12.1, AI)



45. Substance A most likely is:
   - A. oxygen.
   - B. carbon dioxide.
   - C. fats.
   - D. water.

(D)

46. The structure involved in handling Substance A is the:
   - A. contractile vacuole.
   - B. food vacuole.
   - C. mitochondrion.
   - D. nucleus.

(A)

47. If Substance B is a protein, then C probably is:
   - A. amino acid.
   - B. glucose.
   - C. carbon dioxide.
   - D. water.

(A)

48. Assume that Substance B is a protein. The structure in the *Amoeba* involved in handling Substance B is the:
   - A. contractile vacuole.
   - B. food vacuole.
   - C. mitochondrion.
   - D. nucleus.

(B)

49. If Substance B is glucose, then Substance D could be:

A. carbon dioxide.
B. oxygen.
C. ATP.
D. starch.

(A)

---

50. Asexual reproduction can be an advantage to *Paramecium*. This is because:

A. by this means cells never grow old.
B. offspring are produced that are adapted to the environment.
C. new contractile vacuoles are produced with each division.
D. the cytoplasm of *Paramecium* is renewed continuously.

(inv. 12.1, AI, B)

51. The contents of a structure in *Paramecium* were analyzed. They contained 98 percent starch and 2 percent glucose. Contents removed from the same structure three minutes later were 12 percent starch and 88 percent glucose. The data suggest that this structure functions in:

A. reproduction.
B. excretion.
C. digestion.
D. enzyme formation.

(inv. 12.1, AI, C)

52. Sexual reproduction in *Paramecium* involves the exchange of:

A. nuclear material between identical individuals.
B. nuclear material between individuals of two mating types.
C. materials between the micronucleus and the macronucleus in one individual.
D. cytoplasmic material between identical individuals.

(inv. 12.1, AI, B)

53. A structure present in a protozoan in fresh water disappears when the protozoan is flooded with salt water. This structure probably controls:

A. protein digestion in the cell.
B. salt metabolism in the cell.
C. water content of the cell.
D. movement by the cell.

(inv. 12.1, AI, C)

54. Fission of *Paramecium* produces two small offspring. In time, each attains the size of the one that divided to form them. This size increase results from:

A. use of molecules from digested food in growth of cell structures.
B. large amounts of water diffusing into the cells.
C. repeated cell division to form a multicellular organism.
D. storage of proteins in special structures of the cell.

(inv. 12.1, AI, A)

55. The structure described above moves around within *Paramecium*. Analysis of its contents over time showed a decrease in both sugar and starch and an increase in nitrogen compounds. This suggests which other functions for this structure?

A. transportation of food and excretion of wastes
B. exchange of gases and digestion of proteins
C. transportation of food and exchange of gases
D. digestion of proteins and excretion of wastes

(inv. 12.1, AI, A)

56. Movement in *Paramecium* is in a forward spiral. This suggests that the *Paramecium* cell is:

A. flexible.
B. shaped like a pointed cone.
C. rigid.
D. moved by something other than cilia.

(inv. 12.1, AI, A)

57. *Paramecium* provides a convenient model for studying animal function because:

A. its structure is almost identical to that of higher animals.
B. it is easy to grow and observe and carries on basic functions common to all organisms.
C. its enzyme systems are easily observed in a laboratory.
D. it is unique in structure and function and offers a contrast to most organisms.

(inv. 12.1, AI, B)

The next seven items provide evidence that a particular structure is associated with one of the functions given in the key. Use the key to indicate which function most likely is involved.

(inv. 12.1, AI)

KEY: A. removal of excess water
B. digestion
C. excretion of fluid wastes
D. oxygen–carbon dioxide exchange

____ 58. Removal of the structure causes the organism to swell:

(A)

____ 59. The organism suffocates if the structure is blocked:

(D)

____ 60. The structure is known to convert starch to sugar:

(B)

____ 61. The structure is known to contain urea:

(C)

____ 62. The structure does not function if no water enters the organism:

(A)

____ 63. The structure operates at an increased rate when the organism is very active:

(D)

____ 64. The structure breaks large pieces into small particles by mechanical action:

(B)

---

65. Which is characteristic of algae? They are:

A. all of the following
B. all aquatic.
C. either unicellular or colonial.
D. photosynthetic autotrophs.

(12.9, D)

66. Which describes the structure of algae?

A. all of the following
B. colonial
C. multicellular
D. unicellular

(12.9, A)

67. How are algae similar to plants? Both have:

A. all of the following
B. cell walls composed of cellulose and lignin.
C. chloroplasts with chlorophyll.
D. motile gametes.

(12.9, C)

68. The presence or absence of pigments other than chlorophyll is one basis for the classification of:

A. algae into phyla.
B. flowering plants into classes.
C. bryophytes into orders.
D. conifers into families.

(12.9, A)

69. Protists that are commonly called seaweeds are:

A. algae.
B. fungi.
C. lichens.
D. mosses.

(12.9, A)

Use the following taxonomic groups of algae as responses for the next five items. Any one group may be used more than once or not at all.

(12.10–12.12)

KEY: A. chlorophyta (green algae)
B. chrysophyta (golden algae)
C. phaeophyta (brown algae)
D. rhodophyta (red algae)

____ 70. found in the oceans; may be very large (100m long); have cellulose cell walls; store food as oil or an unusual polysaccharide but not as starch:

(C)

____ 71. includes diatoms, which have silicon shells and store food as oils:

(B)

____ 72. thought to be ancestors of plants:

(A)

____ 73. are terrestrial and aquatic (marine and freshwater); store food as starch; have cellulose cell walls; reproduce sexually and asexually:

(A)

____ 74. some grow deep in the ocean; cells walls contain cellulose and agar-like carbohydrates; their chloroplasts may have evolved from cyanobacteria:

(D)

---

75. Why are fungi important to us?

A. all of the following
B. Many are decomposers.
C. Many cause diseases, especially in plants.
D. Some are used to make chemical and food products.

(12.13, A)

76. Fungi are classified mainly on differences in:

A. composition of cell walls.
B. pigments in their cells.
C. sexual reproductive structures.
D. size and shape of vegetative structures.

(12.13, C)

77. The threadlike structures of fungi that anchor the organisms and absorb food products are called:

A. hyphae.
B. rhizoids.
C. shoots.
D. stalks.

(12.13, A)

78. Why can fungi survive in some very extreme environments where there is little water? They:

A. are made up of threads.
B. are microscopic.
C. have cell walls made of cellulose.
D. have cell walls made of chitin.

(12.13, D)

79. Why is it advantageous for fungi to produce large numbers of spores?

A. Spores live a very short time.
B. Very few spores have a chance for fertilization.
C. Very few spores find a suitable environment for growth.
D. Mutation rates of fungi are low.

(12.13, AI, C)

80. All true fungi are:

A. heterotrophic.
B. autotrophic.
C. phototropic.
D. photosynthetic.

(12.13, A)

81. A fungus such as *Rhizopus* gets its food by:

A. secreting enzymes to digest starch into soluble compounds.
B. absorbing food from cells of its host.
C. producing it from raw materials of the soil.
D. chemical reactions similar to photosynthesis.

(12.14, A)

82. Fertilization in the common bread mold requires:

A. a liquid medium.
B. two different mating strains.
C. production of flagellated gametes.
D. a special series of cell divisions like mitosis.

(12.14, B)

83. Some species of mushrooms are always poisonous, other species are never poisonous. This indicates that the:

A. production of poison is under genetic control.
B. poisonous mushrooms grow in different types of soil than the non-poisonous ones.
C. two types have different abilities to absorb chemicals from the soil.
D. two types use different material for nutrition.

(12.15, AI, A)

84. The "imperfect fungi" are so called because biologists find no evidence in them of:

A. chlorophyll.
B. rhizoids.
C. sexual reproduction structures.
D. vascular tissue.

(12.17, C)

85. Why are many fungi that act as decomposers dependent upon each other? Some:

A. are really consumers that feed on other fungi.
B. are really producers that provide food for other fungi.
C. break down material into compounds that can be broken down further by other fungi.
D. produce antibiotics that are used by other fungi.

(12.18, C)

Use the following data and hypotheses to evaluate the next six items.

(12.18, AI)

In many areas of the United States oak trees are threatened by a disease called oak wilt. The disease is caused by a fungus.

Question: How is the disease spread?

Hypothesis I: The disease is spread from tree to tree by fungus-eating insects.

Hypothesis II: The disease is spread from tree to tree by contact of the roots.

Use the following key to identify each statement. (Suggestion: Read all of the items before responding to any of them.)

KEY: A. tends to support Hypothesis I
B. tends to support Hypothesis II
C. tends to support both hypotheses
D. tends to support neither hypothesis

____ 86. The disease-causing fungus can grow on ash, dogwood, wild cherry, and other trees:

(D)

____ 87. The top of a diseased tree begins to wilt and turn brown followed by a similar condition in the lower limbs:

(A)

____ 88. In a stand of oaks different tree roots grow close together:

(B)

____ 89. If one tree in a group of oak trees dies, all the trees die:

(B)

____ 90. Insects feed on the mats of fungus which grow under the bark of diseased trees:

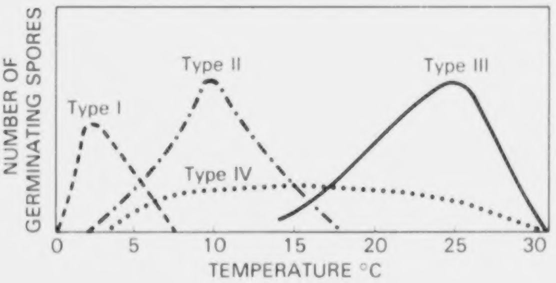
(A)

____ 91. Trees can be artificially infected by placing the causative fungus in a cut or injury in the bark:

(A)

The next eight items refer to the following graph. Fungi of a certain species produce four kinds of spores. Data obtained about the germination of these spores indicate that each type of spore tends to develop into a new fungus in a certain range of temperatures.

(inv. 12.3, AI)



92. From the data it appears that the four kinds of spores give this species of fungus the advantage of being:

A. able to reproduce in wet or dry, hot or cold environments.
B. adapted to most different environmental temperatures.
C. best suited to reproduce in a middle range of temperatures.
D. suited to survive in aquatic or terrestrial environments.

(B)

93. The spores that germinate in the greatest range of temperatures are Type:

A. I.
B. II.
C. III.
D. IV.

(D)

94. The spores that germinate in the narrowest range of temperatures are Type:

A. I.
B. II.
C. III.
D. IV.

(A)

95. At the appropriate temperatures, the spores that produce the greatest numbers of fungi are Types:

A. I and II.
B. I and III.
C. II and III.
D. II and IV.

(C)

96. Fungi, like other organisms, face competition in most environments. This particular fungus appears best adapted to succeed in:

A. all environments.
B. environments of moderate temperatures.
C. no particular environments.
D. very warm and very cool environments.

(D)

97. The chief advantage that the Type IV spores confer on this species of fungus is the ability to:

A. adapt to varying conditions of humidity.
B. maintain a population at freezing temperatures.
C. overcome competition at all temperatures.
D. survive most temperature variations.

(D)

98. The factor that determines which types of spores the fungus will actually produce at a given temperature is:

A. competition.
B. germination rate.
C. not in the data.
D. nutrition.

(C)

99. Before you can predict where this fungus is found in nature, you would need data on its survival in relation to:

A. available minerals.
B. available moisture.
C. inorganic materials.
D. other decomposers.

(B)

---

100. Mycorrhizae are examples of:

A. commensalism.
B. mutualism.
C. parasitism.
D. predation.

(12.19, B)

The following information refers to the next seven items.

(12.1–12.20; inv. 12.2, 12.3; AI)

Four finger bowls were set up as follows:

Bowl A	Stale, moistened bread
Bowl B	Warm, 10-day-old beef soup
Bowl C	Pond water
Bowl D	Crushed grapes in water

In which bowl would you expect to find:

____ 101. the fewest decomposers?

(C)

____ 102. the most bacteria?

(B)

____ 103. ciliates and flagellates?

(C)

____ 104. algae?

(C)

____ 105. the most mold?

(A)

____ 106. the most yeast?

(D)

____ 107. producers and consumers?

(C)

---

108. A lichen is difficult to classify because, on microscopic examination, it reveals two interrelated:

A. algae.
B. fungi.
C. mosses.
D. organisms.

(12.20, D)

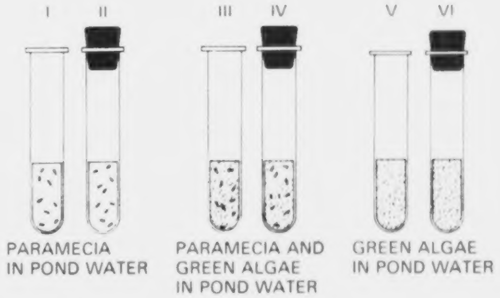
109. If lichens involve a mutualistic symbiotic relationship between two different organisms, then you should be able to:

A. easily grow the organisms separately.
B. grow one organism, but not the other.
C. remove one organism and the other will grow better.
D. separate the organisms but not easily grow them.

(12.20, AI, D)

The next four items are based on the following experiment with green algae (microscopic producers) and paramecia (microscopic consumers that do not fed on green algae). All the tubes were exposed to normal day/night conditions.

(12.1–12.20, AI)


I
II
III
IV
V
VI
PARAMECIA IN POND WATER
PARAMECIA AND GREEN ALGAE IN POND WATER
GREEN ALGAE IN POND WATER

110. In which tube will carbon dioxide increase most rapidly?

A. I
B. II
C. III
D. IV

(B)

111. In which tube are the organisms likely to live longest?

A. I
B. III
C. IV
D. V

(D)

112. Which tubes probably will show no different results whether kept in the light or the dark?

A. I and II
B. II and III
C. III and IV
D. IV and V

(A)

113. The organisms that live longest do so because they have no need for:

A. air.
B. energy.
C. food organisms.
D. light.

(C)

The next four items are based on an experiment in which five drops on methyl red and a brass screw were added to each of four test tubes. Organisms X and Y were then placed in the tubes as indicated in the table, and the tubes were sealed. The brass screws kept the organisms out of the methyl red.

(12.1–12.20, AI)

Methyl red is an indicator that changes from yellow to red in the presence of carbon dioxide.

Tube	**Organism**	**Conditions**	**Color of indicator**
I	X	Dark	Red
II	X	Light	Red
III	Y	Dark	Red
IV	Y	Light	Yellow

114. In which tube was the carbon dioxide used?

A. I
B. II
C. III
D. IV

(D)

115. What are the probable natures of the organisms in terms of how they would fit into a food chain?

A. X is a producer, Y a consumer.
B. X and Y are both consumers.
C. X and Y are both producers.
D. Y is a producer, X a consumer.

(D)

116. In which sealed tubes should you expect the organisms' lives to be endangered first?

A. I, II, and III
B. I, II, and IV
C. I, III, and IV
D. II, III, and IV

(A)

117. A useful control for this experiment would be a fifth sealed tube containing only air and:

A. a brass screw.
B. five drops of methyl red.
C. organism X.
D. organism Y.

(B)

Chapter 13
Eukaryotes: Plants

1. In which habitat would you *not* find modern plants?
   - A. deserts
   - B. lakes and ponds
   - C. oceans
   - D. prairies

   (13.1, C)

2. Which is an advantage for the first plants that were able to survive on land?
   - A. all of the following
   - B. abundance of CO_2 and O_2
   - C. abundance of minerals
   - D. more light

   (13.1, A)

3. Which is most likely the major limiting factor for land plants?
   - A. carbon dioxide
   - B. light
   - C. minerals
   - D. water

   (13.1, D)

4. Which is most likely the major limiting for plants in an aquatic environment?
   - A. carbon dioxide
   - B. light
   - C. minerals
   - D. water

   (13.1, B)

5. Present day plants most likely evolved from:
   - A. brown seaweeds.
   - B. fungi.
   - C. multicellular green algae.
   - D. photosynthetic prokaryotes.

   (13.1, C)

For the next six items, match a letter from the key to each item.

(13.1)

KEY: A. algae
B. bryophytes
C. vascular plants

____ 6. mosses:

(B)

____ 7. ferns:

(C)

____ 8. plants that bear seeds in cones:

(C)

____ 9. terrestrial plants without true leaves, stems, or roots:

(B)

____ 10. protists:

(A)

____ 11. flowering plants:

(C)

---

12. All green land plants can be divided into:
    - A. flowering plants and conifers.
    - B. bryophytes and vascular plants.
    - C. conifers and club mosses.
    - D. dicots and monocots.

    (13.1, B)

13. Man's chief food plants are:
    - A. dicots.
    - B. fungi.
    - C. conifers.
    - D. monocots.

    (13.2, D)

14. Food is stored in flowering plant (Anthophyta) seeds in the:

A. cotyledons.
B. endosperm.
C. cotyledons or endosperm.
D. fruit.

(13.2, C)

15. Which adaptations are important for plants survival on land?

A. all of the following
B. protection against water loss
C. protection for reproductive cells
D. structures to get water and carbon dioxide

(13.2, A)

16. The characteristic most used in classifying plants by species is their:

A. cellular structure.
B. leaf cellulose.
C. reproductive structures.
D. vascular tissue.

(13.2, C)

17. A second characteristic used to classify plants in broad groupings is the presence or absence of:

A. cellular structure.
B. leaf cellulose.
C. reproductive structures.
D. vascular tissue.

(13.2, D)

18. Flowering plants that live for a single growing season are called:

A. annuals.
B. grasses.
C. perennials.
D. vines.

(13.2, A)

19. A leaflike part of a plant embryo in a flowering plant is called a:

A. blade.
B. cotyledon.
C. petiole.
D. sepal.

(13.2, B)

20. Monocots and dicots are classified according to whether their plant embryos contain one or two:

A. cotyledons.
B. roots.
C. segments.
D. shoots.

(13.2, A)

21. Plants with special water and food conducting tissues are classified as:

A. bryophytes.
B. mycophytes.
C. sporophytes.
D. vascular plants.

(13.3, D)

22. The structures of most vascular plants that serve the same functions which rhizoids serve in ferns and mosses are called:

A. flowers.
B. fruits.
C. roots.
D. stems.

(13.3, C)

23. What do vascular plants have that mosses do *not* have?

A. all of the following
B. cuticle
C. stomates with guard cells
D. xylem

(13.3, A)

24. Scientists hypothesize that two lines of plants evolved: one with vascular tissue, a waxy covering and true roots; the other lacking those structures. This means:

   A. all of the following
   B. one line is restricted to dry habitats, the other line is not.
   C. one line is restricted to moist habitats, the other line is not.
   D. only big plants are found in one line and only small plants in the other.

   (13.2–13.3, C)

25. Which best explains why mosses do not grow very tall? They:

   A. have airborne spores.
   B. have swimming sperm.
   C. lack chlorophyll in chloroplasts.
   D. lack specialized vascular and support tissue.

   (13.3, D)

26. True mosses and their relatives, liverworts and hornworts, are the only group of green land plants that lack:

   A. cells.
   B. chlorophyll.
   C. spores.
   D. vascular tissue.

   (13.3, D)

27. The stems, leaves, and roots of most flowering plants differ from the roughly similar structures of true mosses by having:

   A. cells.
   B. cell walls.
   C. growing tissues.
   D. vascular tissues.

   (13.3, D)

28. The evolution of pollen grains:

   A. depended upon the presence of water.
   B. enabled alternation of generations in plants.
   C. enabled plants to reproduce sexually without water.
   D. resulted when vascular tissue evolved.

   (13.4, C)

29. In mosses, as in animals, sperm are released and swim to the ova. This makes mosses dependent upon:

   A. aquatic environments.
   B. internal fertilization.
   C. pools of rainwater.
   D. secretion of semen.

   (13.5, C)

30. How does the gametophyte generation of a plant species differ from the sporophyte generation?

   A. It is always the dominant generation.
   B. It is diploid in all its cells.
   C. It is haploid in all its cells.
   D. It produces the spores.

   (13.5, C)

31. Meiosis in plant species occurs in:

   A. each generation.
   B. every embryo.
   C. every other generation.
   D. fertilized ova.

   (13.5, C)

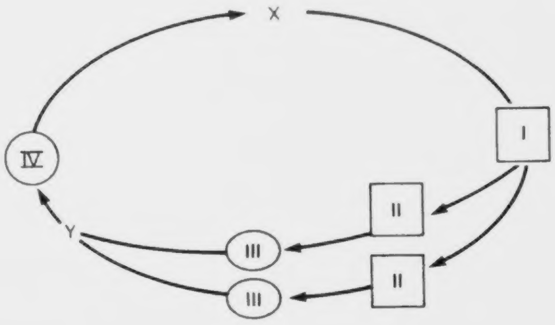
32. In mosses, zygotes develop in:

   A. gametophytes.
   B. sporophytes.
   C. pistils.
   D. seeds.

   (13.5, A)

Use the following diagram for the *next* four questions.

(13.5, AI)



33. In mosses the dominant generation is:

A. I.
B. II.
C. III.
D. IV.

(B)

34. Where does meiosis occur in the moss life cycle?

A. between II and III
B. between IV and I
C. X
D. Y

(C)

35. In mosses which structure can be carried by wind?

A. I
B. II
C. III
D. IV

(A)

36. The familiar small green moss plants are:

A. I.
B. II.
C. III.
D. IV.

(B)

37. In flowering plants, fertilization occurs within the:

A. endosperm.
B. pistil.
C. seed.
D. stamen.

(13.6, B)

38. The tops of pistils often are covered by a sticky substance that helps catch:

A. insects.
B. pollen.
C. raindrops.
D. sperm.

(13.6, B)

39. Which of these plants produces flowers?

A. fern
B. grass
C. moss
D. pine

(13.6, B)

40. The four principal structural parts of most flowers are:

A. cotyledons, petals, stamens, pistils.
B. pollen, stamens, pistils, petals.
C. sepals, petals, stamens, pistils.
D. stamens, pistils, pollen, seeds.

(13.6, C)

41. A pollen grain in a flowering plant develops from a:

A. gamete.
B. sperm.
C. spore.
D. testis.

(13.6, C)

42. The seeds and spores of seed plants differ in that:

A. seeds are diploid, spores haploid.
B. seeds are reproductive, spores vegetative.
C. spores are sexual, seeds asexual.
D. spores are zygotes, seeds embryos.

(13.6, A)

43. Which part of a flower produces pollen?

A. petal
B. pistil
C. sepal
D. stamen

(13.6, D)

44. In flowering plants, a new sexually reproduced individual begins with the union of two:

A. diploid cells.
B. diploid nuclei.
C. haploid nuclei.
D. unlike spores.

(13.6, C)

45. In flowering plants, the spores that precede development of gametes are:

A. all pollen.
B. diploid.
C. eight-celled.
D. haploid.

(13.6, D)

46. Plants whose reproductive structures are flowers are classified as:

A. Anthophyta.
B. Bryophyta.
C. Coniferophyta.
D. Lycophyta.

(13.6, A)

47. Insects play a part in the reproduction of flowering plants by:

A. eating fruits.
B. eating the tops of pistils.
C. pollinating flowers.
D. scattering seeds.

(13.6, C)

48. How do sperm reach the egg of a flowering plant?

A. by gravity
B. by swimming
C. through the air
D. through the pollen tube

(13.6, D)

49. A pollen grain is a:

A. gamete.
B. gametophyte.
C. spore.
D. sporophyte.

(13.6, B)

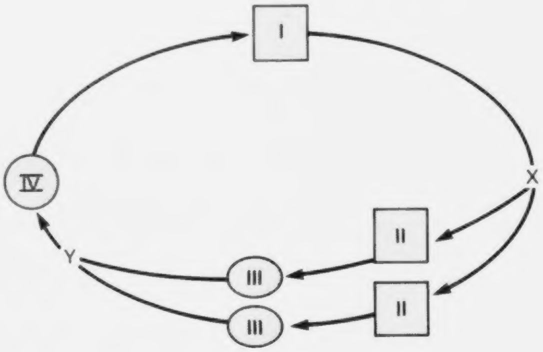
50. What is the relationship between pollination and fertilization in a flower?

A. Fertilization and pollination are the same event.
B. Fertilization must occur before pollination can occur.
C. Pollination must occur before fertilization can occur.
D. Pollination is sexual, fertilization asexual.

(13.6, C)

For the next four items use the following diagram of the life cycle of a flowering plant.

(13.6, AI)



51. If I is the mature flowering plant and II its microscopic gametophytes, then X must be:

A. fertilization.
B. gamete.
C. meiosis.
D. zygote.

(C)

52. If the two IIs are the microscopic gametophytes in the flowers, then the two IIIs are:

A. egg nuclei and sperm nuclei.
B. pollen and spores.
C. two cotyledons in the seed.
D. zygotes and seeds.

(A)

53. Y represents:

- A. a seed.
- B. fertilization.
- C. gametes.
- D. meiosis.

(B)

54. The structure at IV, which develops into the mature flowering plant at I, is a(n):

- A. egg sac.
- B. gamete.
- C. pollen.
- D. seed.

(D)

---

55. Rhizoids serve a function in mosses that is served in most other terrestrial plants by:

- A. flowers.
- B. leaves.
- C. stems.
- D. roots.

(13.7, D)

56. Bryophytes are terrestrial plants that lack:

- A. cellulose.
- B. chlorophyll.
- C. leaflike parts.
- D. vascular tissue.

(13.7, D)

57. Which pair of terms means the same?

- A. club moss and true moss
- B. conifer and club moss
- C. horsetail and fern
- D. scouring rush and horsetail

(13.8, D)

Use the following groups of plants as responses for the next four items. Any one group may be used more than once or not at all.

(13.8–13.9)

KEY: A. club mosses (Lycophyta)
B. ferns (Pterophyta)
C. horsetails (Sphenophyta)
D. whisk ferns (Psilotum)

____ 58. Contain silica. Harsh to the touch. Called scouring rushes:

(C)

____ 59. Similar to the oldest fossil vascular plants:

(D)

____ 60. Low growing evergreens. With branching horizontal stems and cones at tips of upright stems:

(A)

____ 61. Spores borne in cases in clusters on the undersides of leaves. Gametophytes usually flat thin heart-shaped structures:

(B)

---

62. A spore-producing plant whose stem is underground, and whose leaves are long fronds bearing many leaflets, is probably a:

- A. conifer.
- B. fern.
- C. flowering plant.
- D. moss.

(13.9, B)

63. Which of the following is a conifer?

- A. fern
- B. grass
- C. moss
- D. pine

(13.10, D)

64. All cone-bearing plants that produce seeds are classified as:

A. conifers.
B. dicots.
C. horsetails.
D. monocots.

(13.10, A)

65. A newly discovered species of plant that grows almost one meter tall in forest undergrowth is too large to be a:

A. conifer.
B. fern.
C. flowering plant.
D. moss.

(13.10, D)

66. The seeds of a conifer develop on scales or bracts of:

A. bark.
B. cones.
C. flowers.
D. fruit.

(13.10, B)

67. Confiers lack:

A. all of the following
B. flowers.
C. seeds.
D. vascular tissue.

(13.10, B)

68. All conifers have:

A. flowers.
B. motile cilia-bearing sperm.
C. needle-like leaves.
d. seeds developing in cones.

(13.10, D)

69. Club mosses, horsetails, ferns, and conifers all are:

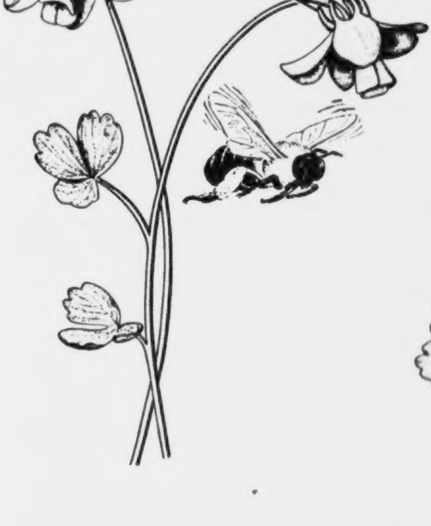
A. flowering plants.
B. bryophytes.
C. conifers.
D. vascular plants.

(13.10, D)

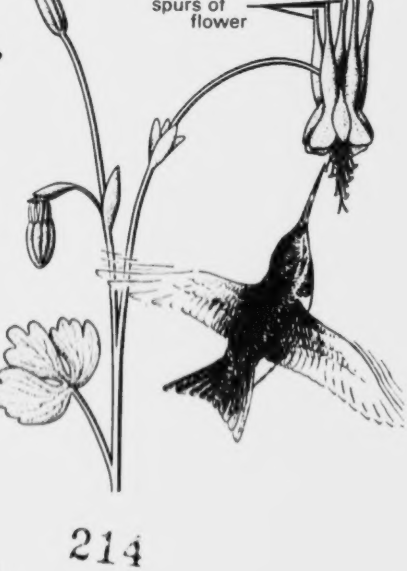
The next five items are based on the following drawings. Drawing A is a European columbine and a European bumblebee. Drawing B is a western American columbine and a hummingbird.

(13.11, AI)

A. European columbine



B. Western American columbine



70. Bees are sensitive to colors at one end of the color spectrum, the violet and ultraviolet wavelengths. European columbines are pollinated almost exclusively by bumblebees, so that you might expect the flower color to be:

A. blue.
B. purple.
C. red.
D. white.

(B)

71. To a bird, the colors that are brightest are at the opposite end of the color spectrum from ultraviolet and violet. The western American columbine is pollinated by hummingbirds, so that you might predict the flower color to be:

A. blue.
B. purple.
C. red.
D. white.

(C)

72. The two columbines can be cross-pollinated. The offspring are fertile and sometimes have their flower colors reversed. Planted in the wild, a western American columbine with the European columbine's color could be expected to:

A. attract bees.
B. attract hummingbirds.
C. displace the native columbine in Europe.
D. displace the native columbine in the western U.S.

(A)

73. Bees can successfully pollinate a columbine with short spurs, but not one with long spurs. Therefore, a western American columbine with the European columbine's color could be predicted to:

A. adapt to self-pollination.
B. die out in nature.
C. succeed in Europe.
D. succeed in the western U.S.

(B)

74. Columbines and other flowers absorb part of sunlight and reflect part of it. In particular they reflect wavelengths that match their color. Yet bees are often observed in flowers that are in the hummingbird's color range of attraction. This observation suggests that the flowers the bees visit also reflect:

A. infrared light.
B. ultraviolet light.
C. violet light.
D. white light.

(B)

---

75. A pair of cotyledons, or a single cotyledon, in the plant embryo divides flowering plants into:

A. annuals and perennials.
B. dicots and monocots.
C. garden plants and wild plants.
D. herbs and trees.

(13.11, B)

The next seven items are based on mehods of pollination of flowering plants. Some plants are self-pollinated; the pollen simply drops from a stamen to a pistil. Others are pollinated by insects that visit different flowers and carry pollen that adheres to their bodies. Still other plants are wind-pollinated; the pollen is airborne from flower to flower. Pollination may also occur from other causes, as when drops of rain float or splash pollen onto a pistil, or as when hummingbirds visit flowers.

The flowers of many plants have both stamens and pistils. Those of other plants may be of two types, one type that has stamens and another that has pistils. In some species these two different types of flowers are on the same plant. In others they are on different plants.

Flower petals also vary from species to species, not only in size, shape, number, and color, but in whether they are present in the flower at all.

(13.11, AI)

76. In plants that produce flowers of two types, one type with stamens and the other with pistils, no enclosing petals could be an advantage to pollination by:

A. hummingbirds.
B. insects.
C. rain.
D. wind.

(D)

77. Short stamens and tall pistils in upright flowers would be a disadvantage to:

A. insect-pollination.
B. rain-pollination.
C. self-pollination.
D. wind-pollination.

(C)

78. An advantage to pollination by any means would be:

A. daily winds and wind direction changes.
B. secretion of a sweet, sticky substance by the tops of pistils.
C. opening and closing of flowers in response to temperature changes.
D. varying light in sunlit and cloudy conditions.

(B)

79. Colorful petals and a scent that attracts should increase the probability of:

A. insect-pollination.
B. rain-pollination.
C. self-pollination.
D. wind-pollination.

(A)

80. Stamens that overhang the pistil, together with petals that meet at the tips and completely enclose the flower, are evidence that the flower is probably:

A. insect-pollinated.
B. rain-pollinated.
C. self-pollinated.
D. wind-pollinated.

(C)

81. When horticulturists plan to cross-pollinate plants whose flowers have both stamens and pistils, they remove the developing stamens from all the flowers on one set of plants. Next they remove the developing pistils from all the flowers on the other set of plants. This action, taken early enough, prevents:

A. any accidental pollination.
B. insect-pollination.
C. self-pollination.
D. wind-pollination.

(13.11, AI, C)

82. An important characteristic in the success of each method of pollination in nature is:

A. abiotic and biotic components.
B. great abundance of pollen.
C. roughly equal numbers of stamens and pistils.
D. small populations of each species.

(13.11, AI, B)

---

83. Insects play a part in the reproduction of flowering plants by:

A. eating fruits.
B. eating the tops of pistils.
C. pollinating flowers.
D. scattering seeds.

(13.11, C)

84. Flowering plants that live for a single growing season are called:

A. annuals.
B. grasses.
C. perennials.
D. vines.

(13.11, A)

85. All flowering plants are classified as:

A. Anthophyta.
B. Bryophytes.
C. Club mosses.
D. Conifers (Coniferophyta).

(13.11, A)

86. A leaflike part of a plant embryo in an angiosperm is called a:

A. blade.
B. cotyledon.
C. petiole.
D. sepal.

(13.11, B)

87. Monocots and dicots are classified according to whether their plant embryos contain one or two:

A. cotyledons.
B. roots.
C. segments.
D. shoots.

(13.11, A)

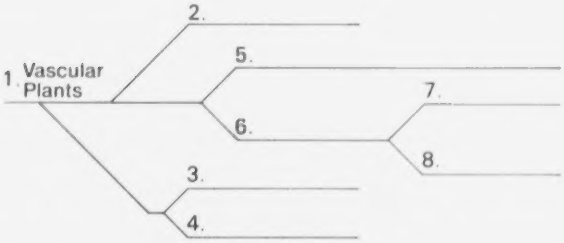
88. Both monocots and dicots are:

A. algalike plants.
B. cone-bearing plants.
C. flowering plants.
D. nonvascular plants.

(13.11, C)

The next seven items are based on the following classification diagram of the vascular plants. As you complete each item you may write in the names of the plant groups if you wish to do so.

(13.8–13.12, AI)



89. If the first two forks in the diagram are for vascular plants that reproduce by spores, then groups 2, 3, and 4 are:

A. club mosses, conifers, and ferns.
B. club mosses, flowering plants, and horsetails.
C. ferns, club mosses, and horsetails.
D. ferns, conifers, and horsetails.

(C)

90. If 5 and 6 are plants that reproduce by seeds but 5 does not produce flowers, then 5 is:

A. flowering plants.
B. club mosses.
C. ferns.
D. conifers.

(D)

91. If 5 and 6 are plants that reproduce by seeds and 6 does not produce cones, then 6 is:

A. flowering plants.
B. club mosses.
C. ferns.
D. conifers.

(A)

92. If the plants in group 6 produce seeds after flowering, then 7 and 8 are:

A. annuals and perennials.
B. herbs and trees.
C. monocots and dicots.
D. wild and garden flowers.

(C)

93. Since the first two forks in the diagram represent vascular plants that reproduce by spores, these plants are probably the:

A. largest vascular plants.
B. most highly developed vascular plants.
C. most numerous vascular plants.
D. oldest living types of vascular plants.

(D)

94. Which three groups of living vascular plants produce trees?

A. club mosses, horsetails, and ferns
B. ferns, flowering plants, and conifers
C. conifers, club mosses, and flowering plants
D. horsetails, flowering plants, and ferns

(B)

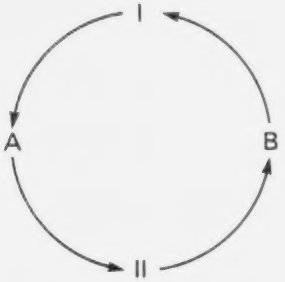
95. One relationship between the vascular plants that reproduce by spores and those that reproduce by seeds is the fact that:

A. pollen develops from spores.
B. seeds enclose spore.
C. spores develop from pollen.
D. spores and seeds are structurally similar.

(A)

The next four items refer to the following diagram of a cycle.

(13.1–13.12, AI)



96. If A is cellular respiration and II is carbon dioxide and water, then B must be:

A. digestion.
B. fermentation.
C. photosynthesis.
D. protein synthesis.

(C)

97. If A is the sporophyte generation and II its spores, then B must be the:

A. bryophyte generation.
B. epiphyte generation.
C. gametophyte generation.
D. tracheophyte generation.

(C)

98. If B is denitrifying bacteria and I is atmospheric nitrogen, then A must be:

A. animals and plants.
B. nitrogen-fixing bacteria.
C. nitrogenous wastes.
D. precipitation.

(B)

99. If A is root absorption of water and II is a plant's vascular system, then B must be:

A. flowers and I spores.
B. leaves and I chlorophyll.
C. photosynthesis and I released oxygen.
D. transpiration and I precipitation.

(D)

---

100. From which part of a flower does a fruit develop?

A. petal
B. pistil
C. sepal
D. stamen

(13.12, B)

101. Both monocots and dicots are:

A. algalike plants.
B. cone-bearing plants.
C. flowering plants.
D. nonvascular plants.

(13.12, C)

Chapter 14
Eukaryotes: Animals

1. An animal that has definite right and left sides is said to show:
   A. bilateral symmetry.
   B. no symmetry.
   C. radial symmetry.
   D. spiral symmetry.

   (14.1, A)

2. Increase in size of an animal is due to an increase in:
   A. complexity.
   B. number of cells.
   C. size of cells.
   D. specialization.

   (14.3, B)

3. Which of the following groups includes animals that show radial symmetry?
   A. coelenterates
   B. crustaceans
   C. flatworms
   D. vertebrates

   (14.4, A)

4. Animals that have a digestive tract or cavity with one opening, radial symmetry, tentacles, and a baglike body are:
   A. annelids.
   B. coelenterates.
   C. roundworms.
   D. mollusks.

   (14.4, B)

5. An animal with a shell, no body symmetry, and a muscular foot is probably a:
   A. chordate.
   B. coelenterate.
   C. mollusk.
   D. sponge.

   (14.6, C)

6. Which of the following taxonomic groups includes the other three?
   A. chelicerates
   B. arthropods
   C. crustaceans
   D. insects

   (14.7, B)

7. Segmented bodies are a characteristic of:
   A. annelids and arthropods.
   B. chordates and coelenterates.
   C. roundworms and mollusks.
   D. flatworms and sponges.

   (14.7, A)

8. Which of the following animals has a segmented body?
   A. clam
   B. earthworm
   C. sponge
   D. roundworm

   (14.7, B)

9. An animal with a ventral nerve cord, an exoskeleton, and jointed appendages would be classified as a(n):
   A. amphibian.
   B. annelid.
   C. arthropod.
   D. roundworm.

   (14.7, C)

10. An animal with anterior and posterior ends, an alimentary canal, gills, and a segmented exoskeleton with paried appendages is likely to be a:
    A. crustacean.
    B. fish.
    C. flatworm.
    D. mollusk.

    (14.7, A)

11. A scorpion can be distinguished visually from any insect by its:

    A. bilateral symmetry.
    B. exoskeleton.
    C. number of legs.
    D. poisonous bite.

    (14.7, C)

12. Arthropods and annelids both have segmented bodies, alimentary canals, and bilateral symmetry. However, only the arthropods have:

    A. dorsal nerve cords and vertebrae.
    B. endoskeletons and paired appendages.
    C. exoskeletons and jointed appendages.
    D. front and rear ends.

    (14.7, C)

13. An animal with a head, thorax, abdomen, wings, an exoskeleton, and three pairs of jointed legs is a(n):

    A. amphibian.
    B. arachnid.
    C. roundworm.
    D. insect.

    (14.7, D)

14. Most living species of animals are classified as:

    A. annelids.
    B. arthropods.
    C. chordates.
    D. echinoderms.

    (14.7, B)

15. The millipedes, centipedes, insects and crustaceans are all grouped together as:

    A. chelicerates.
    B. chordates.
    C. mandibulates.
    D. trilobites.

    (14.7, C)

Use the following animal phyla as responses for the next four items. Any one phylum may be used more than once or not at all.

(14.4–14.7)

KEY: A. annelids
B. coelenterates
C. flatworms
D. roundworms

____ 16. Their bodies are composed of ring like compartments, with many body organs repeated in the segments. Bilateral symmetry and a fluid-filled body cavity:

(A)

____ 17. Aquatic, sessile or drifting animals that have radial symmetry, bodies composed of two tissue layers, and one opening into the digestive tract:

(B)

____ 18. Mostly slender, cylindrical, bilaterally symmetrical animals that have a complete digestive tract with two openings, and a fluid-filled body cavity:

(D)

____ 19. Usually flattened animals with head and tail, bilateral symmetry, 3 tissue layers, and a one-opening digestive tract:

(C)

20. Chordates that have bony endoskeletons with backbones are called:

    A. cartilaginous fishes.
    B. crustaceans.
    C. invertebrates.
    D. vertebrates.

    (14.8, D)

21. Two prominent groups of chordates are the:

    A. amphibians and arthropods.
    B. annelids and fishes.
    C. birds and mollusks.
    D. mammals and reptiles.

    (14.8, D)

22. Which of the following groups of vertebrates has been found in the greatest variety of habitats?

    A. amphibians
    B. bony fishes
    C. mammals
    D. reptiles

    (14.8, C)

23. A newly discovered animal has a baglike body form that is similar to the appearance of animals of several different phyla. However, in a pre-adult stage its young have paired gill slits and a notochord. The newly discovered animal should be classified as a:

    A. chordate.
    B. crustacean.
    C. mollusk.
    D. vertebrate.

    (14.8, A)

24. The notochords of all vertebrate embryos except those of certain fishes are replaced in the adult animals by:

    A. bony vertebrae.
    B. dorsal nerve cords.
    C. flexible exoskeletons.
    D. muscular body walls.

    (14.8, A)

25. Which of the following is a chordate characteristic?

    A. absence of symmetry
    B. dorsal nerve cord
    C. exoskeleton
    D. secretion of a shell

    (14.8, B)

26. Certain fishes such as sharks are classified separately from other vertebrates because they:

    A. breathe by gills.
    B. eat exclusively meat.
    C. have skeletons of cartilage.
    D. lack teeth and jaws.

    (14.8, C)

27. Bats are classified as mammals instead of as birds because they:

    A. are bilaterally symmetrical.
    B. have mammary glands.
    C. lay eggs.
    D. nest in winter.

    (14.8, B)

28. A characteristic that all birds, mammals, reptiles, amphibians, and bony fishes have in common is:

    A. bony endoskeletons.
    B. mammary glands.
    C. paired appendages.
    D. ventral nerve cords.

    (14.8, A)

29. Which of the following taxonomic groups includes the other three?

    A. amphibians
    B. chordates
    C. reptiles
    D. vertebrates

    (14.8, B)

30. Birds and mammals differ from fishes, amphibians, and reptiles in having:

    A. bilateral symmetry.
    B. constant internal temperature.
    C. lungs.
    D. appendages.

    (14.8, B)

The next nine items are based on the following chart showing the classifications of five animals. (14.8, AI)

	Lion	Cat	Dog	Human	Catbird
Phylum	Chordata	Chordata	Chordata	Chordata	Chordata
Class	Mammalia	Mammalia	Mammalia	Mammalia	Aves
Order	Carnivora	Carnivora	Carnivora	Primates	Passeriformes
Family	Felidae	Felidae	Canidae	Hominidae	Mimidae
Genus	*Felis*	*Felis*	*Canis*	*Homo*	*Dumetella*
Species	*leo*	*domesticus*	*familiaris*	*sapiens*	*carolinensis*

31. All five of the animals listed in the chart have:

A. exoskeletons.
B. mammary glands.
C. radial symmetry.
D. spinal cords.

(D)

32. The two animals most closely related are the:

A. cat and catbird.
B. dog and cat.
C. lion and cat.
D. lion and dog.

(C)

33. The animal least closely related to the other four is the:

A. catbird.
B. dog.
C. human.
D. lion.

(A)

34. To obtain a second pair of identical classifications except for species, you could add a:

A. bear next to the human.
B. chicken next to the catbird.
C. monkey next to the human.
D. wolf next to the dog.

(D)

35. The classification data reveal that the lion, cat, and dog are all:

A. able swimmers.
B. carnivores.
C. fast runners.
D. long-lived.

(B)

36. The catbird is the only animal listed in which the:

A. body covering insulates the organism against rapid loss of heat.
B. bony vertebrae enclose and protect the spinal cord.
C. bony vertebrae are fused together into an immovable backbone.
D. front and hind appendages are adapted to two different methods of locomotion.

(D)

37. The differences between a cat and a dog are described at the:

A. class level.
B. family level.
C. order level.
D. phylum level.

(B)

38. The differences between a human and a lion, cat, or dog are described at the:

A. class level.
B. family level.
C. order level.
D. phylum level.

(C)

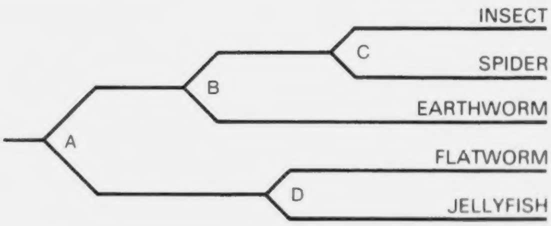
39. The similarities between a cat and a dog are described at the:

A. class level.
B. family level.
C. genus level.
D. order level.

(D)

The next six items are based on the following classification key. A student devised the key for the particular organisms listed. To determine what information the forks in the key provide consider each item in relation to the key.

(14.1–14.8, AI)



At which numbered fork in the key are the contrasting characteristics listed below used to separate the animals?

____ 40. bilateral symmetry versus radial symmetry:

(D)

____ 41. body segmentation versus no segmentation:

(A)

____ 42. jointed appendages versus nonjointed or no appendages:

(B)

____ 43. one body opening versus two body openings:

(A)

____ 44. six legs versus eight legs:

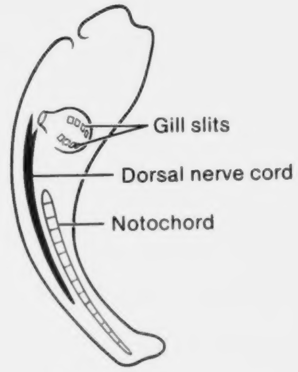
(C)

____ 45. skeleton versus no skeleton:

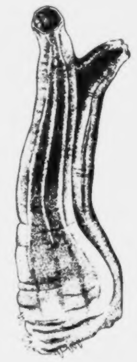
(B)

The next three items refer to the following drawings of a sea squirt. As an adult it lives attached to submerged objects and shows little evidence of at least two of the three structures labeled on the left. Its free-swimming young clearly possess these structures.

(14.8, AI)



SEA SQUIRT
Immature Stage
(free-swimming)



SEA SQUIRT
Adult Stage
(attached)

46. Sea squirts are most commonly observed as adults attached to submerged objects. At this stage they could easily be mistaken for any:

A. amphibian.
B. baglike animal.
C. crustacean.
D. vertebrate embryo.

(B)

47. From the adult stage you would *least* expect the sea squirt to be a:

A. chordate.
B. coelenterate.
C. mollusk.
D. sponge.

(A)

48. The structures labeled in the drawing for the free-swimming stage of a sea squirt clearly relate this animal to embryos of:

A. coelenterates.
B. crustaceans.
C. mollusks.
D. vertebrates.

(D)

---

49. When foodstuffs are taken into a cell and digested in a food vacuole, the process is called:

A. cellular respiration.
B. cellular secretion.
C. extracellular digestion.
D. intracellular digestion.

(14.9, D)

50. A cell is protected against digesting itself with its own enzymes by keeping the enzymes enclosed in:

A. centrosomes.
B. chromosomes.
C. lysosomes.
D. ribosomes.

(14.9, C)

51. In most animals digestion is:

A. external.
B. extracellular.
C. intracellular.
D. nonchemical.

(14.9, B)

52. The process of breaking foods down into molecules small enough to pass through membranes is known as:

A. absorption.
B. cellular respiration.
C. digestion.
D. ingestion.

(14.9, C)

53. An alimentary canal indicates that an animal's digestion is mainly:

A. extracellular.
B. intracellular.
C. muscular churning.
D. swallowing and dissolving.

(14.9, A)

54. Terrestrial animals such as sow bugs and land crabs resemble most aquatic organisms in:

A. breathing through gills.
B. digesting foods intracellularly.
C. having endoskeletons.
D. lacking blood circulation.

(14.10, A)

55. Animals too large for their inner cells to be supplied directly from the external environment have a:

A. body cavity like that of a sponge.
B. glandular system of body ducts.
C. muscular pump that circulates fluid.
D. skeletal framework of hollow channels.

(14.10, C)

56. In very small animals, oxygen and carbon dioxide can often be exchanged between the animals and their environment by:

A. body movements in locomotion.
B. diffusion in and out of the body.
C. evaporation of moisture from the skin.
D. molecular absorption in the kidneys.

(14.10, B)

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57. In an open circulatory system, blood flows from arteries into:

A. body spaces.
B. capillaries.
C. lymph vessels.
D. veins.

(14.10, A)

58. In most terrestrial animals, the moist membranes that exchange oxygen and carbon dioxide are:

A. covered gills.
B. internal air sacs.
C. nasal membranes.
D. tissues lining the mouth.

(14.10, B)

59. In terrestrial vertebrates, nitrogenous wastes are removed by the:

A. kidneys.
B. large intestine.
C. lungs.
D. skin.

(14.11, A)

60. In animals, ammonia, urea, and uric acid are:

A. absorbed.
B. digested.
C. excreted.
D. ingested.

(14.11, C)

61. Very small aquatic organisms and some fishes excrete nitrogenous wastes as:

A. amino acids.
B. ammonia.
C. urea.
D. uric acid.

(14.11, B)

62. In all vertebrates the kidneys are the essential organs for excretion of nitrogenous wastes in the form of:

A. amino acids.
B. ammonia.
C. nitrates.
D. urea or uric acid.

(14.11, D)

63. In some species of fishes, the gills are the chief excretory organs for nitrogenous wastes because the wastes are in the form of:

A. amino acids.
B. ammonia.
C. urea.
D. uric acid.

(14.11, B)

64. Flame cells function in eliminating wastes from:

A. earthworms.
B. insects.
C. planarians.
D. roundworms.

(14.11, C)

65. Individual cells of organisms excrete some of their wastes by:

A. diffusion.
B. kidney action.
C. fluid circulation.
D. lungs or gills.

(14.11, A)

66. Secretion and excretion from a cell differ only in whether the substances involved are:

A. actively transported.
B. diffused through the membrane.
C. molecular in size.
D. wastes, or useful to the organism.

(14.11, D)

For the next eight items, match a letter from the key to each item.

(14.7–14.11)

KEY: A. annelids
B. arthropods
C. chordates
D. echinoderms

____ 67. animals with dorsal nerve cords and endoskeletons:

(C)

____ 68. animals with ventral nerve cords and exoskeletons:

(B)

____ 69. animals with backbones made of vertebrae:

(C)

____ 70. animals with ventral nerve cords, segmented bodies, and no skeletons:

(A)

____ 71. animals with three or more pairs of jointed legs:

(B)

____ 72. segmented animals with an open circulatory system:

(B)

____ 73. jointed-leg animals with a closed circulatory system:

(C)

____ 74. animals that maintain a constant body temperature:

(C)

Use the following animal phyla as responses for the next four questions.

(14.12)

KEY: A. annelids
B. chordates
C. coelenterates
D. flatworms

____ 75. Have nerve networks and two nerve cords extending the length of the body and terminating in an anterior ganglion:

(D)

____ 76. Have only a simple nerve network and a few specialized nerve cells that receive stimuli:

(C)

____ 77. Have a dorsal, tubular nerve cord. Most have a brain at the anterior end:

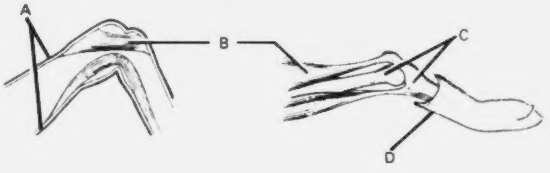
(B)

____ 78. Have a ventral nerve cord with many ganglia along its length and a large ganglion (simple brain) at the anterior end:

(A)

The next three items are based on the following diagram of portions of a hindleg from a grasshopper and a rabbit. Match a letter from the diagram to each item.

(14.13)



____ 79. endoskeleton:

(C)

____ 80. exoskeleton:

(A)

____ 81. striated muscle:

(B)

---

82. How are the reproductive patterns of flowering plants and mammals alike?

A. Body cells are haploid.
B. Fertilization is internal.
C. Individuals are of a single sex.
D. Offspring develop externally.

(14.14, B)

83. When an unfertilized animal egg develops into an offspring, the event is called:

A. cleavage.
B. conjugation.
C. fission.
D. parthenogenesis.

(14.14, D)

84. An example of a hermaphroditic animal is:

A. chickens.
B. earthworms.
C. frogs.
D. owls.

(14.14, B)

85. Sperm are motile and reach an egg by swimming. This means that animals whose eggs are fertilized externally are:

A. aquatic or amphibian.
B. hermaphroditic.
C. mostly microscopic.
D. parthenogenetic.

(14.14, A)

86. A hermaphrodite can produce:

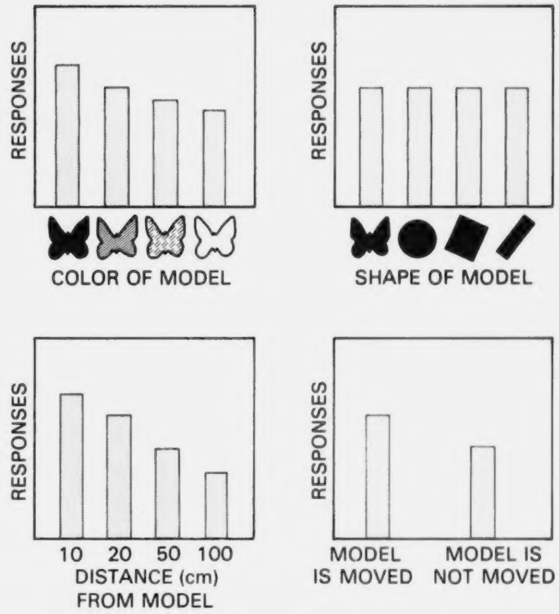
A. diploid gametes.
B. ova and sperms.
C. ova only.
D. sperms only.

(14.14, B)

The next six items refer to the following information.

(14.15, AI)

Several scientists were working with butterflies. They presented the males with different kinds of paper "female butterflies" attached to the end of a fishing line. The results were graphed as follows:



Use the following key to classify the items.

KEY: A. statement supported by the data
B. statement refuted by the data
C. statement not based on the data

____ 87. The males responded only to "females" of realistic shape:

(B)

____ 88. Movement of the models helped attract males:

(A)

____ 89. Mating scents are significant in the behavior of the males:

(C)

____ 90. Males responded positively to every color of "female" presented:

(A)

____ 91. Differing numbers of males responded to variations in every cue except shape:

(A)

____ 92. The males do not respond to models more than 100 cm away:

(C)

---

93. To test for innate behavior, biologists usually:

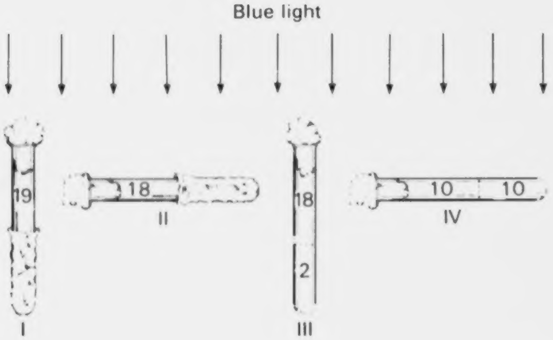
A. determine first whether the animal can learn.
B. hatch an animal from its egg and observe it isolated from its species.
C. remove any stimuli that may be associated with the behavior.
D. study the complexity of the animal's brain.

(14.15, B)

The next five items are based on the following data.

(14.15, AI)

Twenty flies are placed in each of four glass tubes. The tubes are sealed with cotton. Tubes I and II are one-half covered with foil. Tubes III and IV are not covered. The tubes are placed as shown and exposed to blue light for five minutes. The number of flies in the clear part of each tube is shown by the numbers printed on the tubes in the diagram.

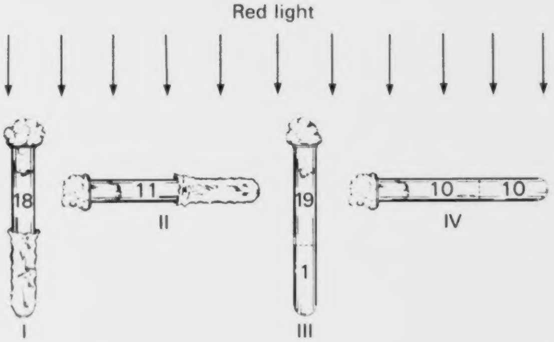


94. These data show that flies respond to:

A. blue light but not gravity.
B. gravity but not blue light.
C. both blue light and gravity.
D. neither blue light nor gravity.

(C)

In a second experiment red light was used instead of blue light. The results are shown in the next diagram.



95. This experiment shows that flies respond to:

A. red light but not gravity.
B. gravity but not red light.
C. both red light and gravity.
D. neither red light nor gravity.

(B)

96. From both experiments it can be concluded that flies react to:

A. red light but not blue light.
B. blue light but not red light.
C. both blue and red light.
D. neither blue nor red light.

(B)

97. Which tubes serve as controls?

A. I and II
B. II and III
C. III and IV
D. I and IV

(C)

98. To measure only the effect of gravity, you should use Tubes:

A. I and II.
B. I and III.
C. II and III.
D. III and IV.

(D)

Chapter 15
The Human Animal: Food and Energy

1. In humans digestion begins in the:

   A. esophagus.
   B. intestine.
   C. mouth.
   D. stomach.

   (15.1, C)

2. Animal nutrition includes three processes called:

   A. ingestion, digestion, and absorption.
   B. ingestion, digestion, and excretion.
   C. secretion, digestion, and absorption.
   D. secretion, digestion, and excretion.

   (15.1, A)

3. Which is *not* a function of the tongue in the digestion of food in humans? To:

   A. keep the food in contact with the teeth
   B. position the food for swallowing
   C. provide information about food taste
   D. supply mucus and enzymes

   (15.1, D)

4. What is peristalsis? The:

   A. constricted upper end of the small intestine
   B. major digestive enzyme
   C. successive waves of muscle contraction in the digestive tract
   D. tube connecting the oral cavity and stomach

   (15.2, C)

5. In humans, protein digestion occurs in the:

   A. mouth and esophagus.
   B. mouth and stomach.
   C. small and large intestine.
   D. stomach and small intestine.

   (15.3, D)

6. Human digestion is completed for proteins, fats, and carbohydrates in the:

   A. esophagus.
   B. large intestine.
   C. small intestine.
   D. stomach.

   (15.3, C)

7. Amino acids are the products of digestion of:

   A. carbohydrates.
   B. fats.
   C. nucleic acids.
   D. proteins.

   (15.3, D)

8. Simple sugars are the products of digestion of:

   A. carbohydrates.
   B. fats.
   C. nucleic acids.
   D. proteins.
   (15.3, A)

9. What role does the pancreas play in digestion? It:

   A. regulates absorption of digested foods from the intestine.
   B. secretes acid into the stomach.
   C. secretes enzymes into the small intestine.
   D. secretes enzymes into the large intestine.

   (15.3, C)

10. In humans, fat digestion occurs in the:

    A. large intestine.
    B. mouth.
    C. small intestine.
    D. stomach.

    (15.3, C)

11. Protein digestion in humans begins in the:

- A. esophagus.
- B. intestine.
- C. mouth.
- D. stomach.

(15.3, D)

12. What kind of chemical environment do stomach enzymes require for their activity?

- A. acid pH
- B. high salt concentration
- C. neutral pH
- D. low salt concentration

(15.3, A)

13. What kind of chemical environment do intestinal enzymes require for their activity?

- A. acid pH
- B. alkaline or basic pH
- C. intestinal hormones
- D. pancreatic hormones

(15.3, B)

For the next four items, match a letter from the key to each item.

(15.3)

KEY: an end product of the digestion of
- A. carbohydrates
- B. fats
- C. proteins

____ 14. glycerol:

(B)

____ 15. amino acids:

(C)

____ 16. fatty acids:

(B)

____ 17. simple sugars:

(A)

---

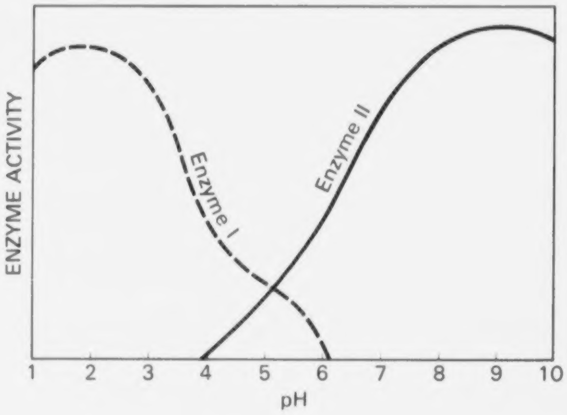
18. What is bile and how does it aid in digestion? It is:

- A. made in the gall bladder and digests fats into fatty acids in the stomach.
- B. made in the liver and breaks fat droplets into small particles in the intestine.
- C. made in the liver and digests proteins into amino acids in the intestine.
- D. made in the pancreas and digests fats into fatty acids in the gall bladder.

(15.3, B)

The next six items are based on the following graph of the activity of two enzymes in the human digestive system. *Assume that the given data include a review of the pH conditions in the mouth, stomach, and intestine.*

(15.3, AI)



Answer the items using this key.

KEY:
- A. statement of reasonable inference from the data
- B. statement contradicted by the data
- C. restatement of the data

____ 19. Enzyme II would be found in the mouth or intestine:

(A)

____ 20. Enzyme I is active only in an acid medium:

(C)

____ 21. Enzyme II may be active in digesting fats:

(A)

____ 22. Enzyme I may be active in digesting carbohydrates:

(B)

____ 23. Enzyme II may be active in digesting carbohydrates:

(A)

____ 24. Enzyme I is secreted only by the stomach:

(A)

The next six items are based on the following key to the parts of the human digestive tract.

(15.3, AI)

KEY: 1. mouth
2. stomach
3. small intestine
4. large intestine

25. Which of the above have absorption as a chief function?

A. 1 and 2
B. 1 and 3
C. 2 and 3
D. 3 and 4

(D)

26. Which of the above have digestion as a chief function?

A. 1 and 2 only
B. 1 and 4 only
C. 2 and 3 only
D. 1, 2, and 3

(D)

27. In which of the above is the pH acid?

A. 1
B. 2
C. 3
D. 4

(B)

28. In which of the above is pancreatic juice added?

A. 1
B. 2
C. 3
D. 4

(C)

29. In which of the above are both salts and water reabsorbed?

A. 1
B. 2
C. 3
D. 4

(D)

30. Small food molecules are absorbed primarily in:

A. 1.
B. 2.
C. 3.
D. 4.

(C)

---

31. Absorption of digested foods in humans takes place through a very large surface area inside the digestive tract, primarily because of:

A. folds and villi in the large intestinal wall.
B. expansion of the stomach's resting size.
C. folds and villi in the small intestinal wall.
D. the long lengths of the two intestines.

(15.4, C)

32. Which best describes the control over the absorption of digested food?

A. Hormones secreted by the pancreas control what is absorbed.
B. pH changes in the digestive tract control what is absorbed.
C. The expansion and contraction of the digestive tract control what is absorbed.
D. There is *no* control mechanism.

(15.4, D)

33. Which is *not* true of the absorption of digested foods?

A. Fatty acids are absorbed in the small intestine.
B. Proteins are absorbed in the stomach.
C. Simple sugars are absorbed in the small intestine.
D. Water is absorbed in the large intestine.

(15.4, B)

34. Absorption of digested foods in humans takes place mainly through the wall of the:

A. large intestine.
B. pancreas.
C. small intestine.
D. stomach.

(15.4, C)

35. Absorption of water in humans takes place mainly through the wall of the:

A. large intestine.
B. pancreas.
C. small intestine.
D. stomach.

(15.5, A)

36. Which is true about cellular respiration?

A. all of the following
B. Energy is released all at once in large amounts.
C. Energy is trapped in ATP molecules.
D. Energy is obtained only from sugars.

(15.6, C)

37. Energy is most quickly available for all animal activities when it is in the form of:

A. ADP.
B. ATP.
C. DNA.
D. glucose.

(15.6, B)

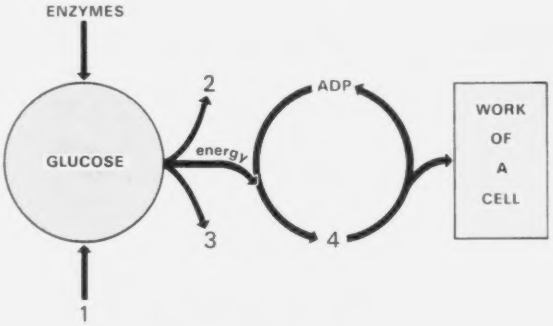
38. To obtain energy from digested nutrients, most animals must have a constant supply of:

A. carbon dioxide.
B. oxygen.
C. pancreatic enzymes.
D. secretin.

(15.7, B)

The next three items are based on the following diagram of cellular respiration.

(15.7, AI)



39. The material needed at 1, before cellular respiration can take place, is:

A. carbon dioxide.
B. oxygen.
C. nitrogen.
D. water.

(B)

40. The two byproducts of cellular respiration at 2 and 3 are:

A. carbon dioxide and oxygen.
B. carbon dioxide and water.
C. nitrogen and water.
D. oxygen and water.

(B)

41. The material at 4 that is made using the energy released by cellular respiration is:

A. ATP.
B. CO_2.
C. DNA.
D. O_2.

(A)

---

42. What is the final electron acceptor in aerobic cellular respiration?

A. ADP
B. carbon dioxide
C. NAD^+
D. oxygen

(15.11, D)

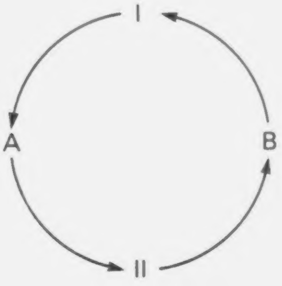
43. Which results from aerobic cellular respiration?

A. all of the following
B. ATP
C. carbon dioxide (CO_2)
D. water (H_2O)

(15.11, A)

The next four items refer to the following diagram.

(15.7–15.13, AI)



44. If I is carbon dioxide and water, and II is glucose, then A is:

A. anaerobic respiration.
B. cellular respiration.
C. fermentation.
D. photosynthesis.

(D)

45. If I is carbon dioxide and water, and II is glucose, then B is:

A. anaerobic respiration.
B. cellular respiration.
C. fermentation.
D. photosynthesis.

(B)

46. This interpretation of the diagram indicates that producers and consumers are interrelated in recycling:

A. energy.
B. enzymes.
C. foods.
D. materials.

(D)

47. The interpretation given the diagram does not indicate the:

A. energy entering and leaving the cycle.
B. interdependence of producers and consumers.
C. opposite natures of Processes A and B.
D. role of materials in the cycle.

(A)

Use the following steps or groups of respiratory reactions as responses for the next four items. Any one response may be used more than once or not at all.

(15.8–15.13)

KEY: A. electron transport system
B. glycolysis
C. intermediate reactions
D. Krebs citric acid cycle

____ 48. Where the breakdown of glucose is started; results in two 3-carbon fragments called pyruvic acid and a small amount of ATP:

(B)

____ 49. CO_2 is removed from 3-carbon pyruvic acid resulting in 2-carbon acetyl unit which attaches to a coenzyme:

(C)

____ 50. Acetyl-coenzyme A (2 carbons) attaches to 4-carbon compound forming a 6-carbon compound which is rearranged and broken back down to the 4-carbon compound, releasing CO_2 and hydrogen atoms:

(D)

____ 51. Hydrogen ions and electrons are passed along compounds embedded in the inner membrane of the mitochondrion; energy from a proton gradient is trapped as ATP:

(A)

---

52. The Krebs cycle plays a central role in cellular metabolism because it:

A. all of the following
B. completes the breakdown of glucose.
C. provides carbon skeletons for biosynthesis reactions.
D. provides hydrogen atoms for the electron transport system.

(15.12, A)

53. The human digestive system has evolved over millions of years to handle a diet high in:

A. fat and salt and low in protein and fiber.
B. fiber and vegetable matter, and low in fat and refined sugar.
C. protein and fat, and low in fiber and refined sugar.
D. refined sugar and protein and low in salt and fiber.

(15.14, B)

54. Which is *not* a recommendation of the 1977 Senate Select Committee on Nutrition and Human Needs?

A. Increase consumption of complex carbohydrates.
B. Increase saturated fat consumption.
C. Reduce intake of refined or processed sugars.
D. Reduce salt intake.

(15.15, B)

55. Why is it important to reduce intake of saturated fats? They:

A. decrease blood cholesterol and the chance of atherosclerosis.
B. decrease blood cholesterol and increase the chance of atherosclerosis.
C. increase blood cholesterol and the chance of atherosclerosis.
D. increase blood cholesterol and decrease the chance of atherosclerosis.

(15.16, C)

56. The best source of carbohydrates in the diet is from:

A. fruits and vegetables.
B. meat.
C. milk.
D. processed foods.

(15.17, A)

57. Why are proteins necessary ingredients of our diets?

A. all of the following
B. to provide quick energy for cell activities
C. to supply a long-term storage of energy for body tissues
D. to supply building blocks for repair and maintenance of body tissues

(15.18, D)

58. Complete proteins contain all of the:

A. amino acids that humans can't synthesize.
B. essential calories and nutrients.
C. four different nucleotides.
D. twenty amino acids.

(15.18, A)

59. The eating disorder characterized by overeating and then inducing vomiting or taking laxatives is:

A. anorexia.
B. bulimarexia.
C. bulimia.
D. malnourishment.

(15.19, C)

60. Which best describes the modern American diet? It now contains:

A. too few kcals.
B. too few saturated fats.
C. too many proteins.
D. too many refined carbohydrates.

(15.20, D)

Chapter 16
The Human Animal: Maintenance of Internal Environment

1. What determines the direction of flow of fluid in a closed circulatory system? The:
   A. number of heart chambers
   B. presence of capillaries
   C. size of the arteries and veins
   D. valves in the tubes

   (16.1, D)

2. In a closed circulatory system, blood flows from arteries into:
   A. body spaces.
   B. capillaries.
   C. lymph vessels.
   D. veins.

   (16.1, B)

3. Valves in veins act to:
   A. lower blood pressure.
   B. prevent backflow.
   C. pump blood.
   D. trap foreign particles.

   (16.1, B)

4. Atria pump blood into:
   A. arteries.
   B. body cavities.
   C. gills or lungs.
   D. ventricles.

   (16.1, D)

5. In humans the wall of the left ventricle is thicker than that of the right ventricle. This is an adaptation that can be explained by the fact that the left ventricle:
   A. is smaller than the right ventricle.
   B. receives only blood low in oxygen content.
   C. pumps blood to the lungs.
   D. pumps blood to all the extremities of the body.

   (16.1, D)

6. Two persons of the same weight produce different quantities of carbon dioxide in the same span of time. The best explanation for this is that one of them:
   A. smokes an occasional cigarette.
   B. is a woman.
   C. is more active than the other.
   D. has not eaten for some time.

   (16.1, C, AI)

7. Hemoglobin is essential to blood because it combines readily with:
   A. nutrients.
   B. oxygen.
   C. thrombin.
   D. urea.

   (16.2, B)

8. In most vertebrates, red blood cells are pushed along in the blood while white blood cells:
   A. build new vessel walls.
   B. form blood clots.
   C. go the opposite direction.
   D. move independently.

   (16.2, D)

9. Red blood cells are red because they:
   A. absorb plasma.
   B. carry oxygen.
   C. contain hemoglobin.
   D. ingest platelets.

   (16.2, C)

10. Most white blood cells destroy:
    A. acids.
    B. damaged capillaries.
    C. nitrogenous wastes.
    D. pathogens.

    (16.2, D)

11. Platelets function in:

    A. blood clotting.
    B. gas transport.
    C. valve regulation.
    D. waste removal.

    (16.3, A)

12. Blood clotting involves the interaction of many clotting factors. Which is the correct sequence?

    A. fibrin–fibrinogen–prothrombin–thrombin
    B. fibrinogen–fibrin—prothrombin activator—prothrombin
    C. prothrombin–thrombin–fibrinogen–fibrin
    D. thrombin–prothrombin–fibrin–fibrinogen

    (16.3, C)

13. Blood plasma in mammals leaves the capillaries carrying nutrients and oxygen, and flows back with wastes into:

    A. arteries.
    B. lymph vessels.
    C. other capillaries.
    D. veins.

    (16.4, B)

14. Which is true of the lymph system?

    A. Cells in lymph nodes remove pathogens and foreign materials.
    B. Cells move into the lymph system from the ventricle.
    C. Lymph is moved by heartbeat (through lymph vessels).
    D. Lymph vessels all empty directly into the heart ventricle.

    (16.4, A)

15. Lymph nodes and white blood cells are similar in function in that they both:

    A. have multi-cellular nuclei.
    B. are blood cells.
    C. contain hemoglobin.
    D. remove harmful bacteria.

    (16.4, D)

For the next nine items use the following key.

(16.4, AI)

KEY: The substance normally
A. passes from the blood through the capillary wall into the fluid that bathes the cells.
B. passes from the fluid that bathes the cells through the capillary wall to the blood stream.
C. *does not* pass through capillary wall.
D. passes in either direction through the capillary wall.

____ 16. water:
(D)

____ 17. protein molecules:
(C)

____ 18. plasma:
(D)

____ 19. bacteria:
(C)

____ 20. red blood cells:
(C)

____ 21. carbon dioxide:
(B)

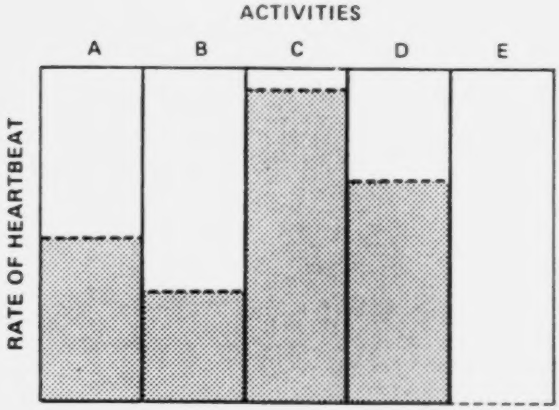
____ 22. glucose:
(A)

____ 23. oxygen:
(A)

____ 24. amino acids:
(A)

The chart below shows the heart rate in an animal during activities A through E. Let segment A represent the normal heart rate when the animal is awake and relaxed. For each of the seven items below indicated the segment of the chart that would correspond to the stated activities.

(inv. 16.1, AI)



____ 25. strenuous exercise such as running up stairs:

(C)

____ 26. sleep:

(B)

____ 27. *daphnia* subjected to low temperatures:

(B)

____ 28. death:

(E)

____ 29. sudden fright:

(C)

____ 30. light exercise such as walking:

(D)

____ 31. ingestion of a mild stimulant:

(D)

32. Which is a part of the body's nonspecific immunity against foreign invaders?

A. all of the following
B. mucus membranes
C. saliva and tears
D. skin

(16.5, A)

33. Which is involved in the inflammatory response?

A. all of the following
B. Antibodies on B cells combine with antigens.
C. B-cells enlarge and divide rapidly.
D. Injured cells release histamines.

(16.6, D)

34. Which is characteristic of T-cells?

A. all of the following
B. They are activated by antigens.
C. They mature in the bone marrow.
D. They produce and display antibodies on their surface.

(16.6, B)

35. Which is *not* true of antibodies? They:

A. are large proteins.
B. are produced by red blood cells.
C. help remove foreign substances.
D. interact or combine with antigens.

(16.6, B)

36. Immunity results from the:

A. ability of plasma cells to produce antibodies.
B. ability of T-cells to produce antigens.
C. conversion of prothrombin to thrombin.
D. release of histamines causing capillaries to become leaky.

(16.6, A)

37. Which would *not* be considered an autoimmune disease?

    A. Multiple sclerosis
    B. Production of antibodies to one's DNA
    C. Rejection of an organ transplant
    D. Rheumatoid arthritis

    (16.7, C)

38. How is the immune system involved in transfusions of different type blood?

    A. Antibodies on donor red blood cells combine with antigens in the recipient plasma.
    B. Antigens on donor red blood cells combine with antibodies in the recipient plasma.
    C. Antigens on donor red blood cells combine with antibodies on recipient red blood cells.
    D. It is *not* involved.

    (16.7, B)

39. In humans, air is drawn into and pumped out of the lungs by movements of the:

    A. arms and shoulders.
    B. epiglottis and larynx.
    C. lung muscles and trachea.
    D. rib muscles and diaphragm.

    (16.9, D)

40. What is the function of the cells lining the air passageways?

    A. all of the following
    B. to clean the air
    C. to moisten the air
    D. to warm the air

    (16.9, A)

41. How does a respiratory system provide sufficient gas diffusion for the needs of a multicellular organism such as the human?

    A. It increases the available surface for gas exchange.
    B. It decreases the available surface for gas exchange.
    C. It increases the amount of oxygen needed by the organism.
    D. It decreases the amount of oxygen needed by the organism.

    (16.9, A)

42. The function of the air sacs of the lungs is to:

    A. provide a large surface area for gas exchange.
    B. warm the air before it is taken up by the circulatory system.
    C. filter harmful bacteria out of the air taken in by the lungs.
    D. separate the lungs into oxygen providing and carbon dioxide removing sections.

    (16.9, A)

43. Which structures are most directly involved in providing oxygen to and removing carbon dioxide from individual cells in a multicellular organism?

    A. capillaries and arteries
    B. arteries and lungs
    C. capillaries and lung air sacs
    D. lung air sacs and the nasal passage

    (16.10, C)

44. The red blood cells are primarily responsible for:

    A. clotting.
    B. transporting food.
    C. transporting oxygen.
    D. killing invading bacteria.

    (16.10, C)

45. Carbon dioxide (CO_2) is transported by the blood mainly:

A. as CO_2 gas bubbles in the blood.
B. as bicarbonate ion (HCO_3^-) in the blood.
C by combining with hemoglobin.
D. by dissolving in the plasma.

(16.10, B)

The next two questions are based on the following experiment.

(inv. 16.3, AI)

A student blows air into a flask containing tap water and phenolphthalein. The liquid becomes colorless; NaOH is added drop by drop until the liquid turns pink.

46. The student then exercises vigorously for five minutes before blowing into the liquid and then adding drops of NaOH. Which best describes the results?

A. Fewer drops of NaOH are required to turn the liquid pink because it has less CO_2 in it.
B. Fewer drops of NaOH are required to turn the liquid pink because it has more CO_2 in it.
C. More drops of NaOH are required to turn the liquid pink because it has less CO_2 in it.
D. More drops of NaOH are required to turn the liquid pink because it has more CO_2 in it.

(D)

47. What is the standard or control for this experiment? Tap water:

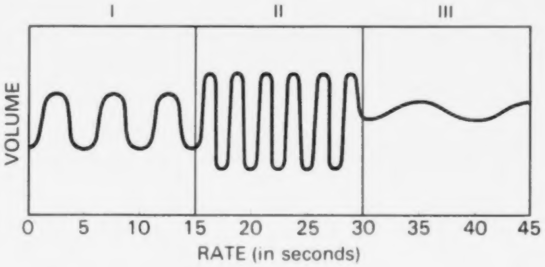
A. with CO_2, but without phenolphthalein.
B. with phenolphthalein and CO_2.
C. with phenolphthalein, but no CO_2.
D. without phenolphthalein or CO_2.

(C)

The next three questions are based on the information and graph of a man's breathing rate shown below.

(inv. 16.3, AI)

The average breathing rate for this man in an awake, sitting position was 12 breaths per minute.



48. Which section of the graph indicates a process of replacing the greatest oxygen deficiency?

A. I
B. II
C. III
D. I and III

(B)

49. What would be the order of the graph sections which demonstrates sleep, climbing stairs, and reading?

A. I, II, III
B. I, III, II
C. III, I, II
D. III, II, I

(C)

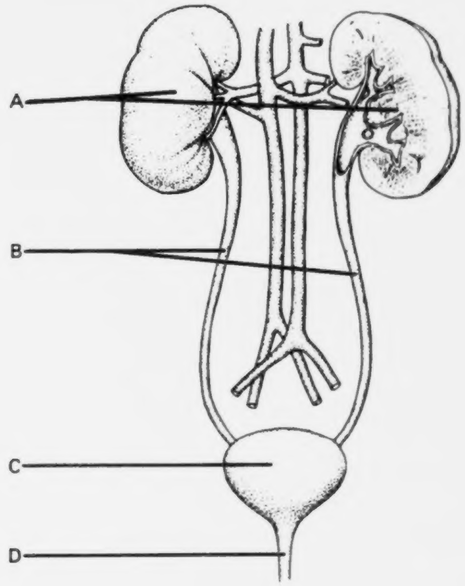
50. Which graph section shows the normal breathing rate for this man?

A. I
B. II
C. III
D. II and III

(B)

The next four items are based on the following diagram. One organ, at the upper right, is cut open in longitudinal section.

(16.11)



51. The two structures labeled A are:

   A. adrenal glands.
   B. kidneys.
   C. parathyroid glands.
   D. testes.

   (B)

52. The two structures labeled B are:

   A. arteries.
   B. enzyme ducts.
   C. sperm ducts.
   D. ureters.

   (D)

53. The structure labeled C is the:

   A. base of the penis.
   B. gall bladder.
   C. thyroid gland.
   D. urinary bladder.

   (D)

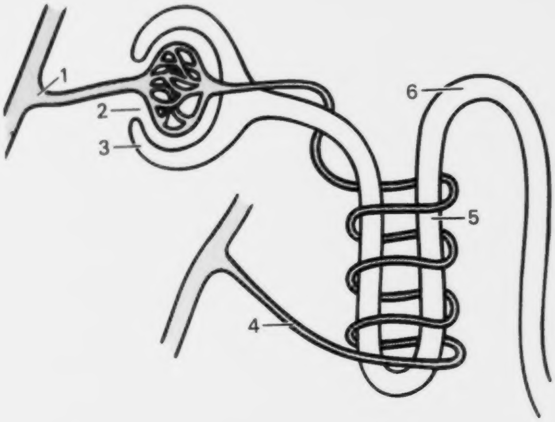
54. The structure labeled D is the:

   A. bile duct.
   B. descending artery.
   C. hormone duct.
   D. urethra.

   (D)

The next six items are based on the following diagram.

(16.11, AI)



55. The illustrated structures make up one:

   A. absorbing unit in the intestine.
   B. air sac in a lung.
   C. capillary bed in liver tissue.
   D. excretory unit in a kidney.

   (D)

56. The structure at I is a:

   A. gland duct.
   B. small artery.
   C. small vein.
   D. ureter.

   (B)

57. Fluid and dissolved materials leave the capillaries in the region of:

A. 1.
B. 2 and 3.
C. 4 and 5.
D. 6.

(B)

58. Needed substances are returned to the blood in the region of:

A. 1.
B. 2 and 3.
C. 4 and 5.
D. 6.

(C)

59. The tube that 4 joins after leaving the coiled region is a:

A. gland duct.
B. small artery.
C. small vein.
D. ureter.

(C)

60. The substance in the tube at 6 is:

A. blood plasma.
B. dilute urine.
C. lymph.
D. water.

(B)

---

61. Which is the functioning kidney unit?

A. alveolus
B. collecting tubule
C. glomerus
D. nephron

(16.11, D)

62. Under normal conditions which substance is completely reabsorbed and returned to the bloodstream by the human kidney?

A. urea
B. water
C. glucose
D. uric acid

(16.11, C, AI)

63. Which is *not* a function of the human kidney? To:

A. produce urea and CO_2
B. regulate blood sugar
C. regulate pH in the body
D. resorb water and excrete salt

(16.12, A)

64. The kidneys help regulate the composition of the blood in several ways other than excreting nitrogenous wastes. This means that the kidneys function in both excretion and:

A. blood circulation.
B. blood pressure regulation.
C. homeostasis.
D. ingestion.

(16.12, C)

The next ten statements are based on the following data. Use the key below to classify these statements.

(16.12, AI)

Composition of plasma, filtrate, and urine (g/100 ml fluid)

Component	Plasma	Filtrate	Urine
urea	0.03	0.03	2.00
uric acid	0.004	0.004	0.05
glucose	0.10	0.10	0.00
amino acids	0.05	0.05	0.00
salts	0.72	0.72	1.50
proteins	8.00	0.00	0.00

KEY: A. a reasonable interpretation of the data
B. an interpretation contradicted by the data
C. there is insufficient evidence to make an interpretation.

____ 65. Calcium salts are higher in concentration in the filtrate than in the urine:

(C)

____ 66. Glucose is the only component completely reabsorbed into the plasma:

(B)

____ 67. Proteins in the plasma break down into amino acids in the filtrate:

(C)

____ 68. The major excreted substances are uric acid, urea, and salts:

(A)

____ 69. Glucose is never found in the urine:

(C)

____ 70. Filtrate is plasma minus blood proteins:

(A)

____ 71. Salt concentration in the urine is twice that in the filtrate:

(A)

____ 72. The membrane between the plasma and the filtrate has large pores in it:

(C)

____ 73. Uric acid is the most abundant component in the urine:

(B)

____ 74. Nitrogen compounds are the main ones excreted by the kidney:

(A)

The next three items are based on the following data on kidney filtrate and urine.

(inv. 16.4, AI)

Substance	**Parts per hundred in the**	
	Filtrate	**Urine**
Protein	0.00	0.00
Glucose	0.10	0.00
Urea	0.03	2.00
Sodium	0.3	0.3

75. A conclusion that water is reabsorbed into the bloodstream as the filtrate passes through the kidney tubules is supported by the data on:

A. glucose.
B. protein.
C. sodium.
D. urea.

(D)

76. A conclusion that energy is expended in reabsorption is supported by the data on:

A. glucose.
B. protein.
C. sodium.
D. urea.

(A)

77. From the two preceding items and the data on sodium, a conclusion can be drawn that:

A. sodium excretion is not affected by reabsorption.
B. sodium is a waste product of cell metabolism.
C. sodium is not acted on by the kidneys.
D. some of the sodium is reabsorbed into the bloodstream

(D)

78. Where does your body obtain most of its heat?

A. evaporation of moisture
B. heat conducted by the sun
C. metabolism in your body
D. radiation from the environment

(16.13, C)

79. Why does your body temperature drop at night?

A. all of the following
B. You wear less clothing.
C. Your kidneys and lungs function more slowly and more heat is lost.
D. Your metabolism slows down.
(16.13, D)

80. The air temperature and humidity in Miami on Day 1 were 36°C and 90% and on Day 2 they were 36°C and 30%. Which would feel hotter and why?

A. Day 1 because the humidity was higher
B. Day 1 because the temperature was higher
C. Day 2 because the humidity was lower
D. Day 2 because the temperature was higher

(16.14, A)

81. Which is involved in human body temperature regulation?

A. all of the following
B. dilation and constriction of blood vessels in the skin
C. shivering
D. sweating

(16.15, A)

82. Which is *not* directly involved in regulating your body temperature? Your:

A. blood vessels
B. muscles
C. skin
D. stomach and intestines

(16.15, D)

83. Where is your body thermostat located? In your:

A. heart
B. hypothalamus
C. lungs
D. skin

(16.15, B)

Chapter 17
The Human Animal: Coordination

Use the following types of muscles as responses for the next seven items. Any one muscle type may be used more than once or not at all.

(17.1)

KEY: A. cardiac muscle
B. smooth muscle
C. striated muscle
D. all of the above

____ 1. voluntary muscle that moves the skeleton:

(C)

____ 2. found in the heart:

(A)

____ 3. found in walls of blood vessels and digestive tract:

(B)

____ 4. composed of fibrils which in turn made up of overlapping, parallel protein filaments:

(C)

____ 5. under control of the nervous system:

(D)

____ 6. often work in opposing pairs:

(C)

____ 7. site of cell respiration:

(D)

---

8. In the cells of which of the following structures would you expect to find the most mitochondria?

A. striated muscles
B. smooth muscles
C. bones
D. tendons

(17.1, A, AI)

9. The two ends of a striated muscle are usually attached to bones on opposite sides of a movable joint. This causes muscles to move the bones as a system of:

A. accordion folds.
B. levers.
C. pulleys.
D. rigid joints.

(17.2, B)

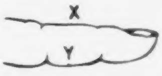
10. The energy used by muscle cells during exercise depletes the supply of:

A. ATP more than creatine phosphate.
B. creatine phosphate more than ATP.
C. muscle heat as warm-up energy.
D. lactic acid as an energy source.

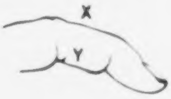
(17.2, B)

The next six items are based on the following drawings of a finger. X and Y indicate opposing finger muscles. Use the key below to classify each of the questions.

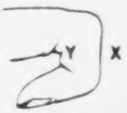
(17.2, AI)



I



II



III

KEY: A. Muscle X is relatively relaxed, muscle Y is contracted.
B. Muscle X is contracted, muscle Y is relaxed
C. Both muscles are relaxed
D. Both muscles are contracted

____ 11. Muscle condition at position I:

(B)

____ 12. Muscle condition at position II:

(C)

____ 13. Muscle condition at position III:

(A)

____ 14. ADP + P → ATP is occurring in both muscles:

(C)

____ 15. Glycogen is being used up by muscle X:

(B)

____ 16. There is mild nerve stimulation to both muscles:

(C)

---

17. The primary benefit of cardiovascular fitness is to:

A. improve the ability of lungs, heart, and blood vessels to deliver oxygen to cells.
B. improve the ability of muscles to move the skeleton.
C. increase pulse and blood pressure.
D. increase the size of the heart and lungs.

(17.3, A)

18. The basic unit of any nervous system is a:

A. brain.
B. ganglion.
C. neuron.
D. synapse.

(17.4, C)

19. In which direction does a motor neuron carry impulses?

A. away from the brain and spinal cord
B. away from muscles and glands
C. toward the brain from the spinal cord
D. toward the spinal cord from sensory receptors

(17.4, A)

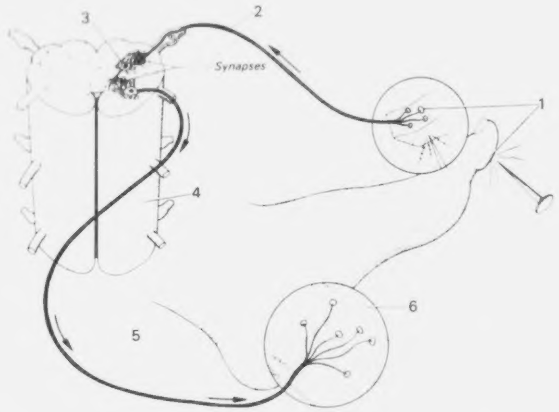
20. What happens during a nerve impulse?

A. all of the following
B. Oxygen and energy (ATP) is required and CO_2 and heat are produced.
C. The plasma membrane becomes more permeable to sodium ions.
D. There is a sudden change in electrical charge of the membrane.

(17.4, A)

The next six items refer to the following diagram of a nerve pathway in humans.

(17.4)



21. The receptor is at:

A. 1.
B. 3.
C. 4.
D. 6.

(A)

22. The motor neuron is:

A. 2.
B. 3.
C. 4.
D. 5.

(D)

23. The associative neuron is:

A. 2.
B. 3.
C. 4.
D. 5.

(B)

24. The receptor is sensitive to:

A. pain.
B. pressure.
C. temperature.
D. touch.

(A)

25. The effector is a:

A. bone.
B. gland.
C. muscle.
D. tack.

(C)

26. The sensory neuron is:

A. 2.
B. 3.
C. 4.
D. 5.

(A)

---

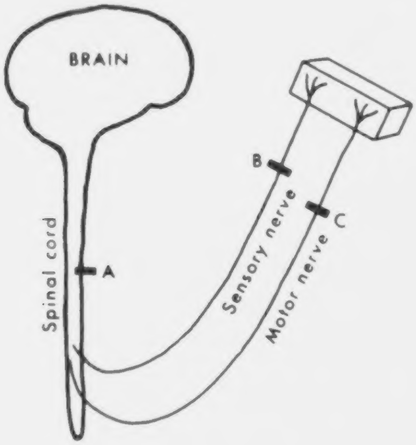
27. Impulses pass from one neuron to another:

A. where their cell membranes come in contact.
B. across a space between them called the synapse.
C. where they are physically joined to the cytoplasm of a receptor.
D. along the length of the nerve fiber.

(17.4, B)

The next four items are based on the following diagram and information. Use the key to classify the statements.

(17.4, AI)



The letters A, B, and C represent regions of a human nervous system which might be blocked by a local anesthetic.

KEY: A. block is at A
B. block is at B
C. block is at C
D. no block

____ 28. The person can move his toe, but cannot feel the movement:

(B)

____ 29. The person has feeling in his toe, but cannot move it:

(C)

____ 30. When the skin of the toe is stimulated, the toe moves and the person knows it is moving:

(D)

____ 31. When the skin of the toe is stimulated, the toe moves, but the person does not know it is moving:

(A)

The next four questions are based on the following information:

(17.4, AI)

A "hot foot" results when a match is stuck in a shoe and lit. Very soon the one receiving the "hot foot" (1) jerks his leg, (2) feels the pain, and (3) grabs his foot.

32. The first change in the nervous system would be at the:

    A. sensory nerve.
    B. receptor.
    C. motor nerve.
    D. muscle.

    (B)

33. After the stimulus is received, it travels first in the:

    A. sensory neuron.
    B. spinal cord.
    C. brain.
    D. motor neuron.

    (A)

34. Which of the events require a motor neuron?

    A. 1 only
    B. 1 and 2 only
    C. 1 and 3 only
    D. 1, 2, and 3

    (C)

35. Which of the events requires a functioning brain?

    A. 1 only
    B. 1 and 2 only
    C. 2 and 3 only
    D. 1, 2, and 3

    (C)

---

36. In vertebrates the central nervous system is usually defined as the:

    A. brain and its major parts.
    B. brain and hypothalamus.
    C. brain and spinal cord, together with nerves connected directly to them.
    D. brain, spinal cord, and autonomic nerves.

    (17.5, C)

Use the following parts of the central nervous system as responses for the next two items:

(17.5)

KEY: A. cerebellum
B. cerebrum and cerebral cortex
C. hypothalamus
D. spinal cord

____ 37. coordinates muscles and controls balance:

(A)

____ 38. deals with thinking, reading, speaking, and learning:

(B)

---

39. Which is *not* a function of the autonomic nervous system? Control of:

    A. blood pressure
    B. peristaltic movements in the gastrointestinal tract
    C. thinking
    D. urine formation and excretion

    (17.6, C)

40. In mammals the nervous and endocrine systems are linked by the:

    A. autonomic nervous system.
    B. hypothalamus.
    C. prostaglandins.
    D. sensory receptors.

    (17.6, B)

41. Endocrine glands have no ducts. Their secretions are delivered by the:

A. associative neurons.
B. bloodstream.
C. kidneys.
D. liver.

(17.8, B)

42. Which is characteristic of endocrine glands?

A all of the following
B. Many are controlled by hormones released by the pituitary.
C. Their hormones are released through tubules or ducts.
D. They are under the direct control of the central nervous system.

(17.8, B)

43. Most chemical substances that help regulate growth, development, and cell activity are known as:

A. effectors.
B. enzymes.
C. hormones.
D. neurons.

(17.8, C)

Two hypotheses are possible explanations for the control of pancreatic secretion into the intestine:

(17.9, AI)

Hypothesis I. Nerves stimulate the pancreas to secrete its enzymes into the intestine.

Hypothesis II. A hormone in the blood causes the pancreas to secrete its enzymes into the intestine.
For the next eight items use the key to classify each of the following observations or experiments as they relate to the two hypotheses.

KEY: A. supports hypothesis I only
B. supports hypothesis II only
C. supports both hypotheses
D. does not support either hypothesis

____ 44. The pancreas is stimulated when food enters the small intestine of a normal animal:

(C)

____ 45. When a nerve leading to the pancreas is stimulated, the pancreas secretes enzymes:

(A)

____ 46. When the nerves leading to the pancreas are cut and weak acid is placed into the intestine, the pancreas secretes enzymes:

(B)

____ 47. If there is no food in the stomach or intestine of a normal animal, the pancreas does not secrete enzymes:

(D)

____ 48. The circulatory systems of two dogs are connected. Food is placed in the intestine of one dog. The pancreas in both dogs secretes enzymes:

(B)

____ 49. The blood from the intestine of an animal was prevented from reaching the pancreas. When the nerve leading to the pancreas was stimulated, the pancreas secreted enzymes:

(A)

____ 50. The lining of an intestine was ground up. An extract of this preparation, when injected into the blood of an animal, caused the pancreas to secrete enzymes:

(B)

____ 51. Chemical analysis reveals that enzyme differences exist in pancreatic juices secreted when nerves are stimulated, and when nerves have been cut but the bloodstream has not been interrupted:

(C)

52. From the data in the preceding items it can be concluded that the pancreas secretes its pancreatic juices, with enzymes, because of:

A. nerve stimulation.
B. a hormone in the blood.
C. both A and B.
D. neither A nor B.

(C)

Use the following key to answer the next five items. (17.9)

KEY: hormone produced by
A. adrenal glands
B. pancreas
C. pituitary gland
D. thyroid gland

____ 53. a hormone that regulates the rate of cellular respiration in body cells:

(D)

____ 54. a hormone that raises blood pressure, speeds up heartbeat, and helps an individual through a sudden emergency:

(A)

____ 55. a hormone that is essential to the metabolism of glucose:

(B)

____ 56. a hormone that increases the percentage of glucose in the blood:

(A)

____ 57. a hormone that directs another gland to produce its hormone:

(C)

---

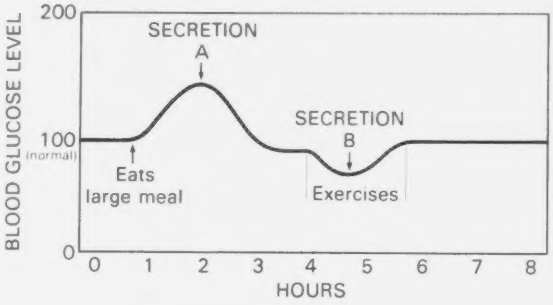
58. The human liver changes glucose to stored glycogen, and glycogen back to glucose. In this way it helps regulate the level of

A. glucose in the blood.
B. glycogen in the blood.
C. oxygen in the blood.
D. wastes in the blood.

(17.10, A)

The next seven items refer to the following diagram and key. Match a letter from the key to each item.

(17.8–17.10)



KEY: A. adrenals
B. epinephrine
C. glycogen
D. insulin
E. liver
F. pancreas

____ 59. the name of Secretion A, which acts on high blood glucose following a meal:

(D)

____ 60. the organ that produces Secretion A:

(F)

____ 61. the compound into which excess blood glucose is changed:

(C)

____ 62. the organ in which the compound made from excess glucose is stored:

(E)

____ 63. the name of Secretion B, which acts when exercise has caused the blood glucose level to drop:

(B)

____ 64. the organ that produces Secretion B:

(A)

____ 65. the organ that releases glucose to restore blood glucose level:

(E)

---

66. Which probably did *not* evolve together?

A. communication and longer postnatal dependency
B. language and culture
C. larger brains and shorter postnatal dependency
D. longer prenatal life and larger brains

(17.12, C)

67. Which is unique to humans? Their:

A. ability to communicate
B. development of culture
C. possession of conscious thought and behavior
D. use of tools

(17.13, B)

Use the following categories of psychoactive drugs as responses for the next six items. Any one category may be used more than once or not at all.

(17.17)

KEY: A. depressants
B. hallucinogens
C. stimulants

____ 68. alcohol and tranquilizers:

(A)

____ 69. amphetamines and cocaine:

(C)

____ 70. coffee and tobacco:

(C)

____ 71. marijuana and LSD:

(B)

____ 72. increase initial feeling of alertness, energy and well being:

(C)

____ 73. change sensation, thinking, self-awareness, emotions and space-time perceptions:

(B)

Chapter 18
The Flowering Plant: Form and Function

1. Photosynthesis in a leaf occurs in the:

   A. cuticle.
   B. mesophyll cells.
   C. stomates.
   D. upper epidermis.

   (18.1, B)

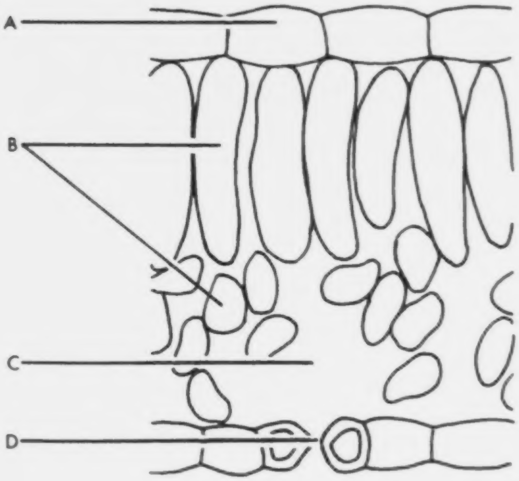
2. In most plants, photosynthesis does not occur in the:

   A. leaf blades.
   B. leaf petioles.
   C. roots.
   D. stems.

   (18.1, C)

The next six items are based on the following diagram of a leaf cross section. Match a letter from the diagram to each item.

(18.1)



___ 3. where a waxy coating is produced:

(A)

___ 4. where chloroplasts are found:

(B)

___ 5. where water is lost by transpiration:

(D)

___ 6. where a leaf can exchange its own gaseous products of photosynthesis and respiration:

(C)

___ 7. where atmospheric carbon dioxide enters the leaf:

(D)

___ 8. where glucose is produced:

(B)

---

9. Air exchange and transpiration in a leaf occur mainly through the:

   A. cuticle.
   B. lenticels.
   C. stomates.
   D. vein openings.

   (18.2, C)

10. A plant's loss of water by transpiration is controlled by:

    A. the cambium.
    B. guard cells.
    C. lenticels.
    D. root pressure.

    (18.2, B)

Use the following leaf parts as responses for the next four items.

(18.1–18.2)

KEY: A. epidermis and cuticle
B. mesophyll
C. stomates and guard cells
D. veins and vascular tissue

____ 11. Where most of the photosynthesis occurs:

(B)

____ 12. Supply water and minerals:

(D)

____ 13. Transparent layer that prevents water loss:

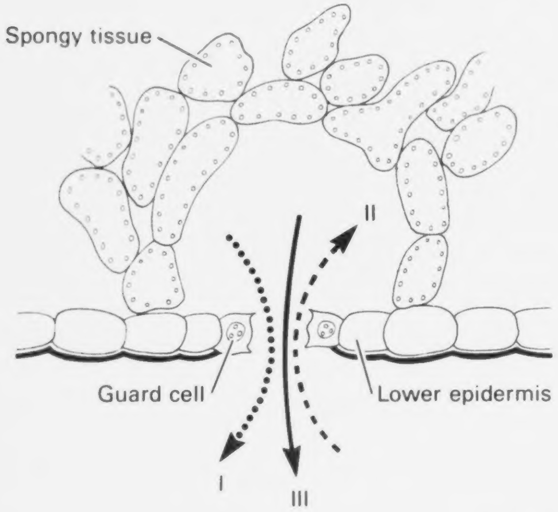
(A)

____ 14. Permit the entry of CO_2:

(C)

The next four items are based on the following diagram.

(18.2, inv. 18.2)



15. The opening through which the arrows are passing is a:
    - A. lenticel.
    - B. stomate.
    - C. tip meristem.
    - D. xylem pit.

(B)

16. Arrow II represents:
    - A. carbon dioxide.
    - B. nitrogen.
    - C. oxygen.
    - D. water.

(A)

17. Arrows I and III represent:
    - A. carbon dioxide and water.
    - B. glucose and water.
    - C. nitrogenous wastes and water.
    - D. oxygen and water.

(D)

18. This diagram represents materials exchange by a leaf during:
    - A. cellular respiration.
    - B. the Calvin cycle of photosynthesis.
    - C. the light-dependent reactions of photosynthesis.
    - D. plant protein synthesis.

(C)

19. Which of the following structures admits air into a woody plant stem?
    - A. lenticels
    - B. stomates
    - C. tracheids
    - D. vessels

(18.3, A)

20. The two main functions of vascular tissue are:
    - A. air exchange and transpiration.
    - B. anchorage and absorption.
    - C. conduction and support.
    - D. new cell growth and differentiation.

(18.4, C)

21. The tubelike structure of phloem tissue is formed by:

A. companion cells.
B. sieve cells.
C. tracheids.
D. vessels.

(18.4, B)

22. The two principal types of vascular tissue in plants are:

A. cambium and cortex.
B. companion cells and cortex.
C. phloem and meristem.
D. xylem and phloem.

(18.4, D)

23. Which of the following are types of vascular tissue?

A. cuticle and epidermis
B. mesophyll and guard cells
C. phloem and xylem
D. root hair cells and root caps

(18.4, C)

24. The primary function of xylem and phloem is:

A. absorption.
B. storage.
C. conduction.
D. photosynthesis.

(18.4, C)

25. The plant tissue specialized for continued mitosis is called:

A. pith.
B. xylem.
C. cambium.
D. bark.

(18.4, C)

26. The chief supporting cells of a stem of a woody plant are found in:

A bark.
B. xylem.
C. phloem.
D. cambium.

(18.4, B)

27. The primary function of living phloem is conducting:

A. soluble foods.
B. dissolved minerals.
C. oxygen and carbon dioxide.
D. water.

(18.4, A)

28. In a very woody stem which of the following tissues would be most abundant?

A. xylem
B. pith
C. cambium
D. phloem

(18.4, A)

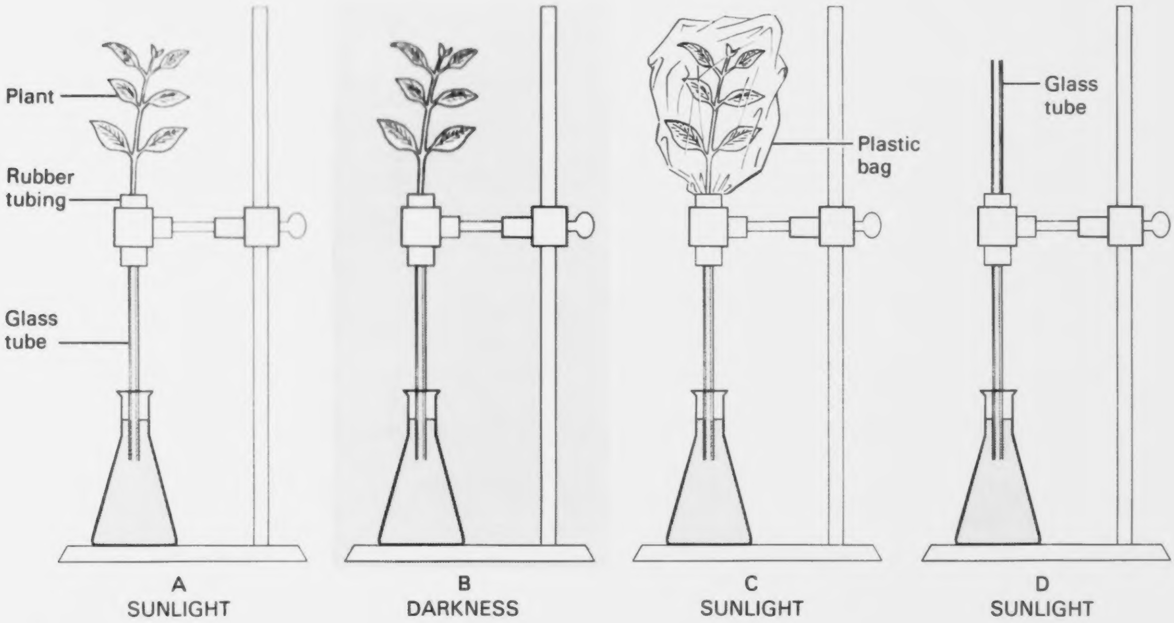
29. The pits between two adjacent tracheid cells permit:

A. equal transmission of glucose between the cells.
B. easy passage of water and dissolved minerals.
C. movement of particles of food between the cells.
D. a convenient location for temporary starch storage.

(18.4, B)

The next eight items are based on the following information and diagram of a plant experiment. Cut stems with leaves were inserted snugly in glass tubes containing water. Three setups were placed on an outside window sill in warm sunlight, and one (B) was kept in the dark.

(18.5, AI)


Plant
Rubber tubing
Glass tube
Plastic bag
Glass tube
A
SUNLIGHT
B
DARKNESS
C
SUNLIGHT
D
SUNLIGHT

30. What plant process is being investigated in this experiment?
    - A. auxin-induced growth effects
    - B. differentiation of leaf cells
    - C. rate of photosynthesis
    - D. transpiration rates in leaves

    (D)

31. The control setup that helps reveal which plant process is being investigated is:
    - A. A.
    - B. B.
    - C. C.
    - D. D.

    (D)

32. The predicted rate of change should be *least* for the control and *greatest* for Setup:
    - A. A.
    - B. B.
    - C. C.
    - D. D.

    (A)

33. Setup C is testing whether:
    - A. atmospheric gases are necessary to the process.
    - B. gases are given off by the process.
    - C. higher humidity will slow the process.
    - D. light is obstructed by a transparent membrane.

    (C)

34. Setup C has *two* controls, the overall control and one of the three experimental setups. These two controls are Setups:

A. A and B.
B. A and D.
C. B and C itself.
D. B and D.

(B)

35. One fault of Setup C is that it changes more than a single experimental variable. Two additional variables affected are:

A. humidity and light.
B. temperature and wind.
C. temperature and humidity.
D. wind and humidity.

(B)

36. For the three experimental setups the predicted rate of change should be *least* for:

A. A or B.
B. B or C.
C. B or D.
D. C or D.

(B)

37. What observation can be expected at the end of the experiment?

A. The three plant stems will be growing in three different directions.
B. Plant B will have the greatest number of mature leaves.
C. Plant C will have produced the greatest concentration of glucose in the flask of water.
D. Water levels in three of the four flasks will be lower.

(D)

---

38. For many non-woody plants, root pressure alone probably could push water upward through the empty cell spaces of:

A. cambium and other meristems.
B. companion and sieve cells.
C. phloem and xylem.
D. tracheids and vessels.

(18.5, D)

39. Water transport to the tops of tall woody plants is explained most satisfactorily by:

A. cohesive lifting action from above.
B. diffusion through empty cells.
C. pumping action from below.
D. root pressure accelerating diffusion.

(18.5, A)

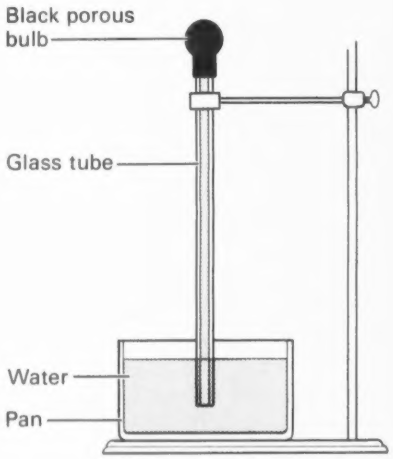
40. Which of the following is most important in moving water from the ground to the leaves in a sequoia tree?

A. breakdown of ATP → ADP
B. oxidation of glucose
C. absorption of minerals by root cells
D. cohesion of water molecules

(18.5, AI)

The next six items are based on the laboratory setup below, which represents the transpiration-cohesion model for water transport in plants.

(18.5, AI)



41. What plant structure or tissue does the glass tube represent?

A. cambium
B. cortex
C. phloem
D. xylem

(D)

42. Why is the black bulb porous?

A. For the model to be correct, air must be free to enter the column of water.
B. Water must evaporate for more water to be pulled upward.
C. The porous bulb, if accidentally squeezed, will not force water back down the "plant."
D. The pores relieve the pressure caused by glucose dissolved in the water.

(B)

43. The tallest trees are 100 meters or more in height, which means that the model should have:

A. an electric pump in the pan.
B. fewer pores in the bulb.
C. narrow tubing 100 meters high.
D. wide-bore tubing 100 meters high.

(C)

44. If the pores in the bulb represent a plant structure, then they most closely approximate:

A. leaf tissue spaces.
B. lenticels in the stem.
C. pores in xylem tubes.
D. stomates in leaves.

(D)

45. If the transpiration-water cohesion hypothesis of water transport is correct and the diagram represents a 300-foot tree, the system would require:

A. water movement in the phloem.
B. a partial vacuum in its leaves to allow atmospheric pressure to raise the water.
C. a column of water continuous for at least 300 feet.
D. root systems which can pump water 300 feet.

(C)

46. The pan of water represents the:

A. root hairs and cell fluid.
B. soil.
C. tree trunk and xylem vessels containing water.
D. intercellular spaces of a leaf and water vapor.

(A)

---

47. Gravity and diffusion fail to account for the rapid transport of the food products of photosynthesis through the living cytoplasm of:

A. companion cells.
B. sieve tubes.
C. tracheids.
D. vessels.

(18.6, B)

48. Movement of sugars through the phloem is dependent on:

A. all of the following
B. active transport of sugars.
C. diffusion of water.
D. flow of sugar-water from higher pressure area to lower pressure area.

(18.6, A)

49. For the day-to-day life of a plant, the most essential function of its roots is:

A. absorption of water and minerals.
B. anchoring the plant.
C. production of auxins.
D. storage of plant food products.

(18.7, A)

50. How are the two root systems related to soil water absorption? Tap roots:

A. absorb deep water, fibrous roots absorb shallow water.
B. absorb shallow water, fibrous roots absorb deep water.
C. and fibrous roots both absorb deep water.
D. and fibrous roots both absorb shallow water.

(18.7, A)

51. Two major functions of roots are:

A. anchorage and absorption of food.
B. anchorage and absorption of water and minerals.
C. photosynthesis and absorption of water and minerals.
D. respiration and absorption of food.

(18.7, B)

52. Water is absorbed by a plant chiefly through:

A. lenticels.
B. root cortex.
C. root hairs.
D. stomates.

(18.8, C)

53. Which of the following is absorbed through the root hairs of plants?

A. proteins
B. carbohydrates
C. oxygen
D. carbon dioxide

(18.8, C)

54. Which is important in mineral uptake by roots?

A. all of the following
B. active transport
C. diffusion
D. osmosis

(18.9, B)

55. The first structure to emerge from a germinating seed is the:

A. cotyledon(s).
B. radical (embryonic root).
C. stem or shoot apex.
D. true leaves.

(18.10, B)

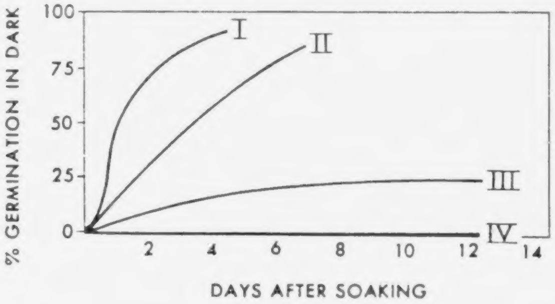
56. Which is a function of the seed coat?

A. all of the following
B. inhibits early germination
C. physically protects the embryo
D. prevents the embryo from drying out

(18.10, A)

The next six items are based on the following graph (labelled I, II, III, and IV) showing the effect upon germination of soaking 4 species of seeds. Use the key to evaluate the statements.

(inv. 18.3 AI)



KEY: The statement is
A. supported on the basis of evidence presented.
B. rejected on the basis of evidence presented.
C. illogical but not refuted by data.
D. logical but experiment is not designed to test it.

____ 57. Species III seeds require more time for germination than the other 3 species:

(D)

____ 58. Species III seeds have a lower germination percentage in the dark than species II seeds:

(A)

____ 59. Species I has the best germination capacity in the dark:

(A)

____ 60. Species IV may require light for germination:

(D)

____ 61. Species II seeds need light for germination:

(B)

____ 62. Soaking makes all 4 seed species germinate:

(B)

The next two questions are based on the following experiment. Germinating corn seeds are cut in half and placed cut-surface down on starch agar. After two days the surface of the agar plate was covered with an iodine solution.

(inv. 18.3, A&I)

63. What would you expect to happen?
    - A. The areas under and around the seeds remain clear; the rest of the plate turns blue.
    - B. The areas under and around the seeds turn blue; the rest of the plate remains clear.
    - C. The entire agar plate remains clear.
    - D. The entire agar plate turns blue.

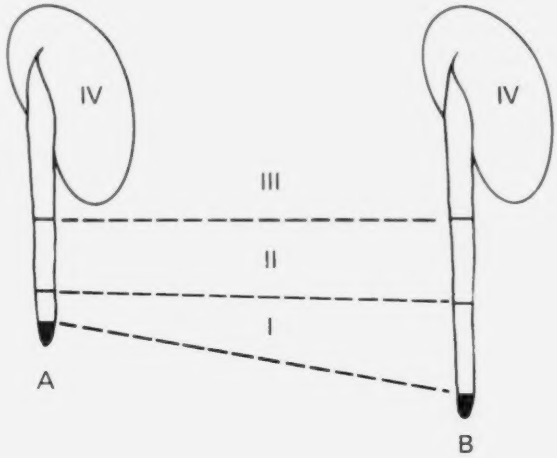
    (A)

64. What would happen if the seed halves were soaked in formaldehyde for an hour?
    - A. The areas under and around the seeds remain clear; the rest of the plate turns blue.
    - B. The areas under and around the seeds turn blue; the rest of the plate remains clear.
    - C. The entire agar plate remains clear.
    - D. The entire agar plate turns blue.

    (D)

The next three items are based on the following drawings of a bean seedling. At Stage A the developing root is marked with waterproof ink. Stage B shows the same seedling two days later.

(inv. 18.4, AI)



65. The region of greatest cell elongation is:
    - A. I.
    - B. II.
    - C. III.
    - D. IV.

    (A)

66. If the seedling is changed in position so that the root is horizontal, auxin will cause the root to:
    - A. grow less rapidly.
    - B. grow more rapidly.
    - C. grow more on one side, bending downward.
    - D. stop growing until changed again in position.

    (C)

67. The effect of the auxin on the horizontal root will be observed mainly in:
    - A. region I.
    - B. region II.
    - C. region III.
    - D. the whole root.

    (A)

68. A "No Hunting" sign was nailed to the trunk of a tree, 1.5 meters above the ground. The tree grows in height at the average rate of 1.2 meters a year. In five years, how high above the ground will the sign be?

A. 1.5 meters
B. 4.5 meters
C. 6.0 meters
D. 7.5 meters

(18.11, A, AI)

69. The primary function of all meristem tissues is:

A. air exchange and transpiration.
B. anchorage and absorption.
C. conduction and support.
D. new cell growth and differentiation.

(18.11, D)

70. Trees grow in diameter as a result of the activity of the:

A. cambium.
B. heartwood.
C. tip meristem.
D. xylem.

(18.12, A)

71. Which of the following is a seed's response to suitable temperature and moisture?

A. estivation
B. germination
C. hibernation
D. migration

(18.12, B)

72. An example of a leaf modified so much that it does not function in photosynthesis is a:

A. cactus spine.
B. fern frond.
C. grass blade.
D. pine needle.

(18.13, A)

73. Which is a leaf adaptation to a dry habitat?

A. all of the following
B. spine-like leaves
C. thick water-storing leaves
D. thick waxy cuticles and sunken stomates.

(18.14, A)

74. Which is an example of leaves modified for food storage?

A all of the following
B. onion
C. potato
D. sweet potato

(18.14, B)

75. What is the advantage of insectivorous plants? They:

A. don't need photosynthesis because of their insect food.
B. get most of their nitrogen compounds from insects.
C. get most of their water from insects.
D. have insect-pollinated flowers.

(18.14, B)

Chapter 19
The Flowering Plant: Maintenance and Coordination

1. The electron microscope has revealed that chloroplasts have a complex internal structure of stacked disk-shaped thylakoids. The thylakoids contain:

   A. chlorophyll, DNA, and RNA.
   B. chlorophyll, other pigments, and protein.
   C. lipids, DNA, and RNA.
   D. protein, carbohydrates, and fats.

   (19.1, B)

2. Several different chlorophylls are known. One of them, chlorophyll *a*, is believed to be present in:

   A. the atmosphere.
   B. all organisms.
   C. all photosynthetic plants.
   D. photosynthetic bacteria.

   (inv. 19.1, C)

3. An absorption spectrum for different chlorophylls shows that the light absorbed and used by plants in photosynthesis is mainly:

   A. blue, green, and yellow.
   B. green, yellow, and orange.
   C. orange, red, and green.
   D. red, blue, and violet.

   (19.2, D)

4. Which is true about sunlight reaching the earth?

   A. all of the following
   B. Much of the light is reflected or absorbed by clouds and dust.
   C. Only 1% is involved in photosynthesis.
   D. Visible light is only a small fraction of sunlight.

   (19.2, A)

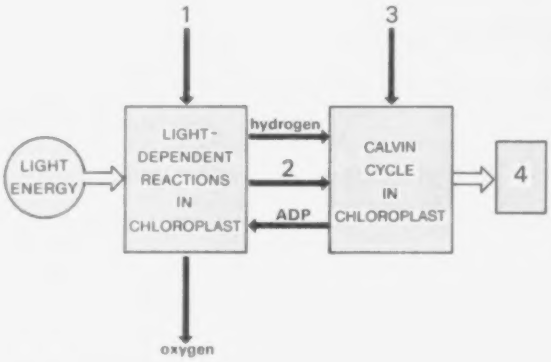
5. About what percentage of the sunlight that falls on the earth is captured in photosynthesis?

   A. 1%
   B. 20%
   C. 50%
   D. 90%

   (19.2, A)

The next six items are based on the following diagram of photosynthesis.

(19.3, AI)


1
3
LIGHT ENERGY
LIGHT-DEPENDENT REACTIONS IN CHLOROPLAST
hydrogen
2
ADP
CALVIN CYCLE IN CHLOROPLAST
4
oxygen

6. The starting material needed at 1 is:

   A. carbon dioxide.
   B. cellulose.
   C. PGAL (phosphoglyceraldehyde).
   D. water.

   (D)

7. The product transfered from the light reactions to the dark reactions at 2 along with hydrogen, is:

   A. ATP.
   B. PGAL.
   C. oxygen.
   D. water.

   (A)

8. The material needed at 3 is:

   A. carbon dioxide.
   B. cellulose.
   C. PGAL.
   D. water.

   (A)

9. The product at 4 is:

   A. cellulose.
   B. chlorophyll.
   C. PGAL.
   D. lactic acid.

   (C)

10. Energy for the reactions on the left in the diagram is supplied by:

    A. ATP.
    B. carbon dioxide.
    C. sunlight.
    D. water.

    (C)

11. Energy for the reactions on the right in the diagram is supplied by:

    A. ATP and hydrogen.
    B. carbon dioxide.
    C. glucose.
    D. sunlight.

    (A)

---

12. The light-dependent reactions of photosynthesis store some of the absorbed energy in:

    A. ATP.
    B. chlorophyll.
    C. sugar.
    D. oxygen.

    (19.4, A)

13. In the light-dependent reactions, electrons flow from PS II to PS I and from PS I to:

    A. ADP.
    B. $NADP^+$.
    C. oxygen.
    D. water.

    (19.4, B)

14. What is produced in the light-dependent reactions?

    A. ATP and NADPH
    B. ATP and O_2
    C. ATP, NADPH, and O_2
    D. NADPH and O_2

    (19.4, C)

15. In the Calvin cycle of photosynthesis, the products of the light-dependent reactions are used to make:

    A. cellulose.
    B. chlorophyll.
    C. lactic acid.
    D. PGAL.

    (19.5, C)

16. The Calvin cycle of photosynthesis does not:

    A. require light.
    B. take place in green leaves.
    C. take place in light.
    D. use energy obtained from light.

    (19.5, A)

17. Which is a product of the Calvin cycle?

    A. ATP
    B. NADPH
    C. oxygen
    D. PGAL

    (19.5, D)

18. PGAL (a 3-carbon sugar), made in photosynthesis, can be used to:

    A. all of the following
    B. enter the respiratory pathway.
    C. form glucose, sucrose, and starch.
    D. regenerate a 5-carbon compound.

    (19.5, A)

19. Both cellular respiration and fermentation require:

    A. enzymes.
    B. minerals.
    C. oxygen.
    D. nitrogen.

    (19.6, A)

20. Under anaerobic conditions, animals produce lactic acid from glucose. Many anaerobic bacteria produce acetic acid, the acid of vinegar. Anaerobic fungi that are used as brewers' yeast produce:

A. acetic acid.
B. alcohol.
C. amino acids.
D. glycerol.

(19.6, B)

21. Compared to fermentation, cellular respiration releases:

A. 3 times more energy.
B. 6 times more energy.
C. 9 times more energy.
D. 18 times more energy.

(19.6, D)

22. Cellular respiration is made possible in place of fermentation by the presence of:

A. heat.
B. lactic acid.
C. oxygen.
D. water.

(19.6, C)

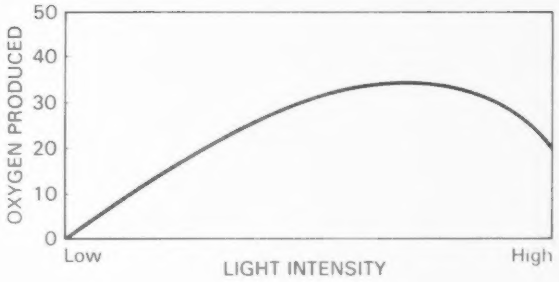
23. How many molecules of ATP can be made from ADP using the energy released from the fermentation of one molecule of glucose?

A. 2
B. 8
C. 18
D. 36

(19.6, A)

The next three items are based on the following graph of oxygen produced by an adequately watered green plant exposed to light of increasing intensities.

(19.7, inv. 19.3, AI)



24. The measurement of oxygen produced is used as a convenient indication of:

A. fermentation rate.
B. growth rate.
C. photosynthetic rate.
D. respiration rate.

(C)

25. The most significant finding is that as the plant increases its activity in response to increasing light intensity, a point is reached at which the:

A. atmospheric carbon dioxide supply drops.
B. plant begins to grow fatigued.
C. tolerance to more light ends.
D. water intake by the plant's roots is blocked.

(C)

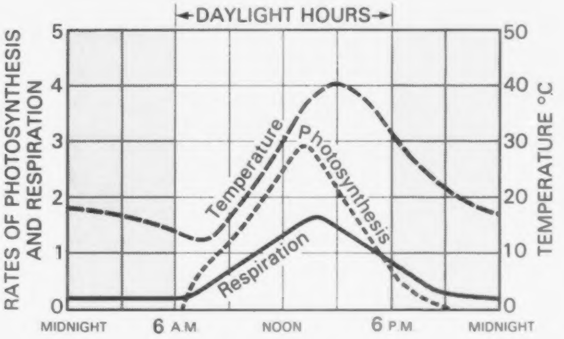
26. The data suggest further experiments with a variety of plants to determine whether different species of plants have different:

A. carbon dioxide requirements.
B. optimum light conditions.
C. photosynthetic products.
D. water evaporation rates.

(B)

The next eight items refer to the following graph. It is based on a study of respiration and photosynthesis in plants. At the time of the study, the overhead position of the sun occurred at 30 minutes past noon.

(19.7, inv. 19.3, AI)



Use the key to evaluate each item.

KEY: A. reasonable statement of interpretation of data
B. restatement of data
C. statement contradicted by data
D. statement not covered by data

____ 27. Photosynthesis does not begin until daylight temperatures begin to increase:

(C)

____ 28. Freezing temperatures prevent photosynthesis but not respiration:

(D)

____ 29. Respiration occurs in the plants continuously:

(B)

____ 30. The continuation of photosynthesis past sundown probably is limited to the synthesis of glucose using ATP and hydrogen generated before sundown:

(A)

____ 31. Animal respiration rates, for nocturnal animals, probably are opposite in their time of peak rate from the peak time for plants:

(D)

____ 32. The coldest hours of the night occur just before dawn:

(B)

____ 33. The highest temperature occurs when the sun is directly overhead:

(C)

____ 34. The peak rate of photosynthesis appears more closely related to light intensity than to temperature, although it also appears to be affected somewhat by temperature:

(A)

---

35. Which is true of plant hormones?

A. all of the following
B. They affect the response of only one plant part.
C. They are effective only in large amounts.
D. They are produced in one place and transported to another.

(19.8, D)

36. Auxins that affect plant growth appear to be produced in:

A. meristems.
B. mesophyll cells.
C. phloem.
D. xylem.

(19.9, A)

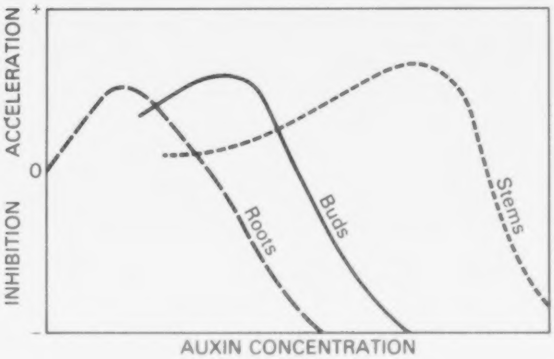
37. Which is a commercial use of auxins? To:

A. all of the following
B. initiate adventitious roots on stem cuttings
C. kill dicot weeds in grass
D. promote fruit growth

(19.9, A)

The next 15 items refer to the growth data plotted on the following graph. Use the key to evaluate each statement.

(19.9, AI)



KEY: A. supported by the data.
B. contradicted by the data.
C. neither supported nor contradicted by the data.

____ 38. Buds produce more auxins than either roots or stems:

(C)

____ 39. Stems do not respond to auxins:

(B)

____ 40. Roots react differently to auxins than do stems:

(A)

____ 41. Plant roots do not respond to auxins:

(B)

____ 42. Roots respond to different auxins than do stems:

(C)

____ 43. Auxin excretion by roots protects the plant from disease:

(C)

____ 44. High auxin concentration increases root growth:

(B)

____ 45. Buds are inhibited by lower auxin concentrations than are stems:

(A)

____ 46. Stem growth is always increased by the addition of auxins:

(B)

____ 47. Root growth is stimulated by smaller amounts of auxins than is stem growth:

(A)

____ 48. Root growth is inhibited by stem growth:

(C)

____ 49. Bud growth is accelerated by stem growth:

(C)

____ 50. High auxin concentrations will stunt plant growth:

(A)

____ 51. There is a different optimum auxin concentration for growth acceleration in roots, buds, and stems:

(A)

____ 52. Root and stem growth are influenced by auxin concentration, but bud growth is not:

(B)

53. Which plant hormone is a gas that promotes fruit ripening?

A. auxin
B. cytokinin
C. ethylene
D. gibberellin

(19.10, C)

54. Which plant hormone promotes cell division?

A. all of the following
B. abscisic acid
C. auxins
D. cytokinins

(19.10, D)

55. Gibberelins often cause a plant to:

A. develop increased resistance to winter kill.
B. develop thicker roots.
C. grow to double or triple its normal height.
D. grow away from light.

(19.10, C)

(*Note to teacher:* The next eight items refer to the following information. The questions can be used as a test section, or for small-group discussion and evaluation, or as a homework assignment.)

(19.10, AI)

Preliminary observations. The leaves of a *Coleus* plant normally fall off when they are 35 to 40 days old. Some leaf blades were removed from young *Coleus* plants, but their petioles were left on the plants. These petioles fell off many days sooner than normal. Small portions of the blades were left on other petioles. These remained on the stem longer than did the petioles alone.

Experiment 1. Leaf blades of one of each pair of leaves were removed from *Coleus* plants. The petioles were left intact. The cut ends of the petioles of one half of the plants were covered with lanolin. This lanolin contained an auxin, indoleacetic acid (IAA). The petioles of the other half of the plants were covered with plant lanolin. The petioles with plain lanolin fell off in a few days. Those treated with IAA remained on the plant much longer.

56. What hypothesis is suggested or being tested by Experiment 1? Auxin:

A. produced by a leaf prevents leaf fall.
B. produced by a leaf promotes leaf fall.
C. produced by a leaf promotes leaf growth.
D. produced by a petiole prevents leaf fall.

(A)

57. Which of the following is a necessary assumption in interpreting the results of Experiment 1? *Coleus* plants:

A. will react to IAA the same way all other plants do.
B. will react to IAA the same way they react to auxin that they produce.
C. represent a genus that may not produce auxins.
D. and all other terrestrial plants produce identical IAA.

(B)

Experiment 2. One of each pair of leaf blades was removed from *Coleus* plants. The petioles were left on the plants. The growing tip at the top of the stem was removed from half of the plants. Petioles of plants with a growing tip fell off in a few days. Petioles of plants without a growing tip remained for a longer period of time.

58. What does Experiment 2 suggest?

A. Auxin produced by the plant's tip meristem travels down the stem and prevents leaf fall.
B. Auxin produced by the plant's tip meristem travels down the stem and promotes leaf fall.
C. Cut stems inhibit leaves lower on the plant from producing auxin.
D. Cut stems cause leaves lower on the plant to produce less auxin.

(B)

Experiment 3. One of each pair of leaf blades was removed from *Coleus* plants. The petioles were left on the plants. The growing tip at the top of the plant was removed from all of the plants. Lanolin was placed at the top of the stem of one half of the plants. Lanolin with indoleacetic acid was placed at the top of the stem of the other half.

Plants treated with the IAA lost the debladed petioles in a few days. Those treated with lanolin alone retained their debladed petioles for a considerably longer time.

59. Where does auxin appear to be produced in *Coleus* plants?
    - A. cut stems and leaves
    - B. cut stems and petioles
    - C. tip meristem and leaves
    - D. tip meristem only

    (C)

60. How many different auxins appear to be involved in whether leaves of *Coleus* are retained or fall from the plant?
    - A. 1
    - B. 2
    - C. 3
    - D. 4

    (A)

61. What determines whether auxin causes leaf fall in *Coleus?*
    - A. amount of auxin produced
    - B. site of production of the auxin
    - C. type of auxin produced
    - D. where the auxin is concentrated

    (D)

62. Why was one leaf of each pair left intact in the three experiments?
    - A. to confirm that auxin is produced by leaves
    - B. to determine the amount of auxin produced by leaves
    - C. to determine normal times of leaf fall
    - D. to verify that leaves have no role in when they fall

    (C)

63. The conclusion to be drawn from the three experiments is that the fall of a leaf of *Coleus* is dependent on the balance between auxin located in the:
    - A. leaf and in the tip meristem.
    - B. lower plant stem and in the leaf or petiole.
    - C. tip meristem and in the lower plant stem.
    - D. petiole and in the leaf blade.

    (B)

64. If a seedling is placed in a light-proof box and strongly illuminated from below the shoot will grow downward. This suggests that:
    - A. positive gravitropism is a stronger influence on shoot growth than positive phototropism.
    - B. positive phototropism is a stronger influence on shoot growth than negative gravitropism.
    - C. negative gravitropism is a stronger influence on shoot growth than positive phototropism.
    - D. negative phototropism is a stronger influence on shoot growth than positive gravitropism.

    (19.12, B, AI)

The next six items relate to growth movements (tropisms) in plants. Using the key below identify each statement.

(19.12, AI)

KEY: A. positive gravitropism
B. negative gravitropism
C. positive phototropism
D. negative phototropism
E. neither gravitropism nor phototropism

____ 65. Roots of seeds germinating in the dark grow downward regardless of how they are oriented:

(A)

____ 66. Bermuda grass strongly illuminated from the left grows to the right:

(D)

____ 67. If the path of tree root growth is obstructed by a rock, the root will grow around the rock:

(E)

____ 68. Plants grown in a light-proof box with a hole cut in it will grow out through the hole:

(C)

____ 69. When lightly touched, the leaves of a *Mimosa* or sensitive plant close:

(E)

____ 70. Shoots of seeds germinated in the dark grow upward regardless of how the seeds are oriented:

(B)

Use the following terms as responses for the next five items. Any one term may be used more than once or not at all.

(19.10–19.13)

KEY: A. bolting
B. gravitropism
C. photoperiodism
D. phototropism

____ 71. a plant's normal flowering response to changes in daylength:

(C)

____ 72. the growth of a plant shoot towards light:

(D)

____ 73. applied gibberellins can cause it:

(A)

____ 74. experimental evidence shows phytochromes are involved:

(C)

____ 75. the downward growth of a root and the upward growth of a shoot:

(B)

---

76. Plant cells in tissue culture often form an undifferentiated mass called a callus. Roots or buds can be initiated by adding:

A. more light.
B. more minerals.
C. the right combination of plant hormones.
D. water.

(19.14, C)

Chapter 20
Selection and Survival

1. An organism's ability to withstand particular environmental conditions is called its:

   A. barrier.
   B. strength.
   C. tolerance.
   D. variation.

   (20.1, C)

2. Which is *not* true about tolerance in organisms?

   A. Different species have different tolerances.
   B. Duration of conditions are important in determining range of tolerance for an organism.
   C. Individuals of a species have the same tolerances.
   D. There are upper and lower limits.

   (20.1, C)

The next ten items relate to desert annual plants. These plants grow only in the rainy seasons. They die and leave the desert floor bare, except for their seeds, during the long dry seasons. The key to their survival is their seeds. If the seeds were to germinate after a rare thundershower, the seedlings would die in the renewed drought that follows. But the seeds do not germinate after one thundershower.

(inv. 20.1, AI)

Question: How is germination regulated in these seeds?

Hypothesis I: Some characteristic of the soil in addition to moisture affects germination.

Hypothesis II: Some characteristic of the seeds during periods of available moisture affects germination.

Use the key to identify which hypothesis, or both, the first nine of the following ten items support.

KEY: A. Hypothesis I
B. Hypothesis II
C. Either or both hypotheses

____ 3. The upper 2.5cm of desert soil, where most seeds are found, gets as wet after 0.25cm of rain as it does after 5cm of rain:

(C)

____ 4. In an experiment, surface desert soil with seeds was put in a pot supplied with water from below. The equivalent of 2.5cm of moisture failed to cause the seeds to germinate:

(C)

____ 5. Evaporation of soil water during droughts leaves surface desert soil high in salt:

(A)

____ 6. Seeds of some species are found to have certain compounds on their seed coats. Gently soaking the seeds activates these compounds. Most of the seeds do not germinate:

(B)

____ 7. One year, 10cm of rain fell in the desert, but neither one distinct rainy season nor any germination occurred:

(C)

____ 8. The more it rains, the more both the soil and the seeds are washed with fresh water, and the more seeds germinate:

(C)

____ 9. Some seeds germinate only after bacteria act on their seed coats. Rain promotes the growth of the bacteria:

(B)

____ 10. Several rains are required before the seeds of some desert annuals will germinate:

(C)

____ 11. In an experiment, water of the same salt concentration as dry desert soil was used to water seeds of desert annuals. Many of the seeds failed to germinate:

(A)

12. A tentative conclusion about the seeds of desert annuals is that they:

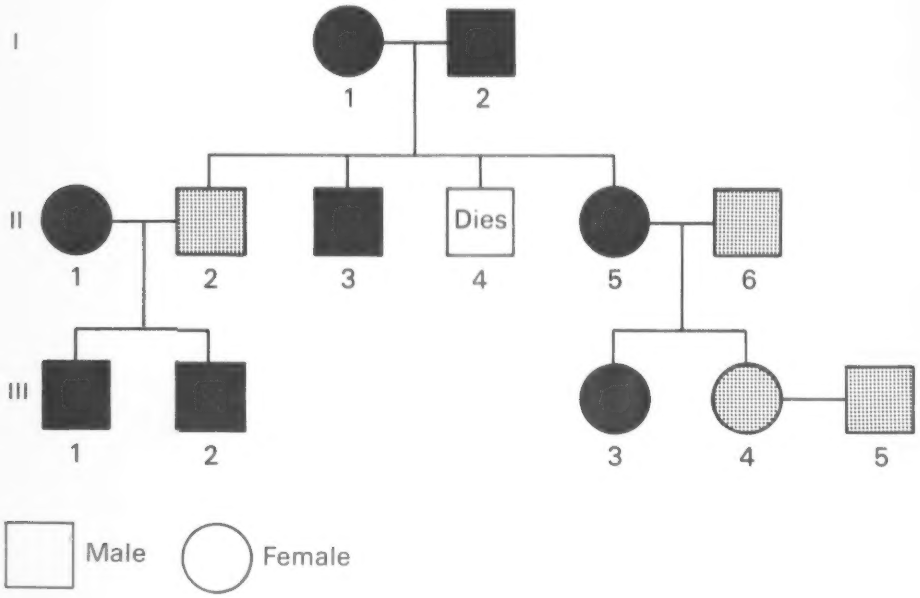
A. germinate on being soaked by a rain.
B. lack adaptations for the rapid germination advantageous in the desert.
C. need bacterial change in the salt content of the soil to germinate.
D. require moisture along with soil and seed coat changes before germinating.

(D)

Use the pedigree chart and the information below to answer the next ten items.

(20.4, AI)

The black squares and circles indicate the sickle-cell *trait*. The grey squares and circle indicate homozygous nonsickling hemoglobin. The white square indicates sickle-cell *anemia*.



13. How many hemoglobin phenotypes are represented in this family?

A. 2
B. 3
C. 4
D. 5

(B)

14. A single pair of genes is involved, indicating that the type of inheritance shown in this pedigree is

A. codominant.
B. dominant.
C. recessive.
D. X-linked.

(A)

Let the symbol H^A represent the gene for nonsickling hemoglobin. Let the symbol H^S represent the gene for sickle-cell hemoglobin.

Use the key to identify each genotype in the next three items.

KEY: A. H^AH^A
B. H^AH^S
C. H^SH^S

____ 15. What is the genotype of Individual I–1?

(B)

____ 16. What is the genotype of Individual II–2?

(A)

____ 17. What is the genotype of Individual II–4?

(C)

18. Two people with the sickle-cell trait marry. What percentage of their children would be expected to have sickle-cell anemia?

A. 100%
B. 50%
C. 25%
D. 10%

(C)

The frequency of the sickle-cell gene is 40 percent in certain areas of Africa. In populations in other parts of Africa it is much lower. In Europe and Asia the frequency of the sickle-cell gene is almost zero.

Question. What causes the frequency of the sickle-cell gene to be so high in one area and so low in another area?

Hypothesis. Sickle hemoglobin has survival value to the human species in some areas.

Additional observation. The frequency of the sickle-cell gene (H^S) is high in areas where malaria occurs. There seems to be evidence that the H^S gene offers some protection against malaria.

Use the key to evaluate the three items that follow.

KEY: Possession of genotype
A. H^AH^A is an advantage.
B. H^AH^S is an advantage.
C. H^AH^S is a disadvantage.
D. H^SH^S is a disadvantage.

____ 19. People who are homozygous for nonsickling hemoglobin do not die from sickle-cell anemia:

(A)

____ 20. People who have the sickle-cell trait are less susceptible to malaria:

(B)

____ 21. People who have two sickle-cell genes die of anemia:

(D)

22. What is the main reason that the genotype H^AH^S has little survival value in the United States?

    A. Malaria is not a common disease in the United States.
    B. Mosquitoes have been eliminated from the United States.
    C. No one in the United States has the H^AH^S genotype.
    D. People have been vaccinated in the United States.

    (A)

---

23. Which is a limiting factor for humans?

    A. all of the following
    B. clean water
    C. energy
    D. space

    (20.4, A)

24. How can the earth's human population be limited?

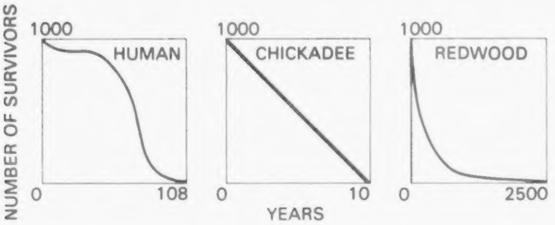
    A. Emigration can increase.
    B. Immigration can increase.
    C. Mortality can increase.
    D. Natality can increase.

    (20.4, C)

The next four items are based on the following three graphs.

(20.5, AI)

PATTERNS OF MORTALITY FOR DIFFERENT ORGANISMS



25. The graph for humans shows that the mortality rate is:

    A. constant for all ages.
    B. high for the young.
    C. low for the elderly.
    D. low for the young.

    (D)

26. The graph for chickadees shows that the mortality rate is:

    A. constant from hatching to 10 years.
    B. greatest from 5 to 7 years of age.
    C. higher among the young than the old.
    D. lower among the young than the old.

    (A)

27. The graph for redwoods shows that the mortality rate is:

    A. constant for all ages.
    B. higher among the young than the old.
    C. lower among the young than the old.
    D. zero after 1000 years of age.

    (B)

28. The chances of living past the first few years of age are greatest for a young:

    A. chickadee.
    B. chickadee or redwood.
    C. human.
    D. human or redwood.

    (C)

---

29. Which is true about limiting factors?

    A. all of the following
    B. They affect only mortality in a population.
    C. They are similar for different organisms living in a similar environment.
    D. They may act differently at different points in the life cycle of an organism.

    (20.5, D)

30. A simplified set of assumptions that enables biologists to do quick calculations about populations and factors affecting them is known as a:

    A. determiner.
    B. model.
    C. sample.
    D. subpopulation.

    (inv. 20.2, B)

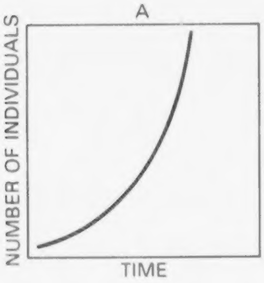
31. A mature population in equilibrium with its natural environment usually tends to:

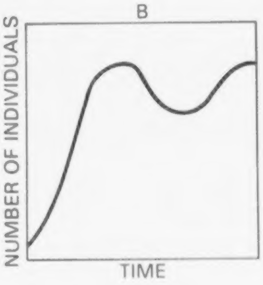
    A. become extinct.
    B. fluctuate slightly in numbers.
    C. grow steadily.
    D. decline.

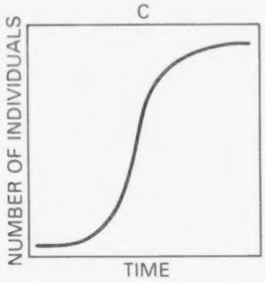
    (20.7, B)

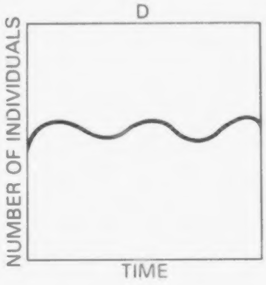
The next item is based on the following graph.

(20.7, AI)







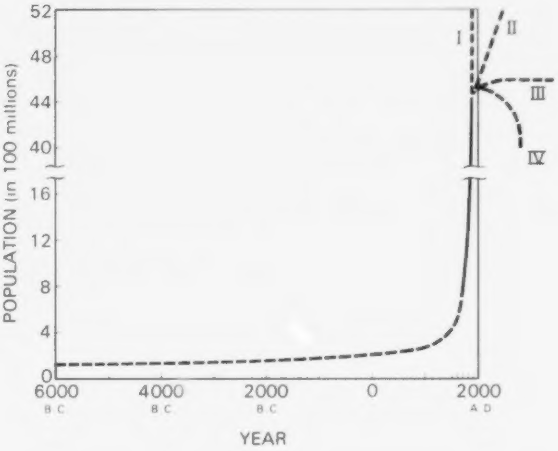


____ 32. Which graph best shows an open population in equilibrium with its environment?

(20.7, AI, C)

The next eight items refer to the following graph of human population growth. The solid-line section of the curve is based on actual data. The dashed-line sections are based on reasonable predictions.

(20.6–20.8, AI)



33. What may have been responsible for the sharp upturn in population growth a few centuries ago?

    A. the Agricultural Revolution
    B. the Industrial Revolution
    C. world exploration
    D. world trade

    (B)

34. A large part of the increase in world population in the 20th century has been due to the:

    A. decrease in natality.
    B. increase in natality.
    C. decrease in mortality.
    D. increase in mortality.

    (C)

35. Can the slope of the line representing actual data remain the same indefinitely?

A. Yes, human ingenuity adds to the carrying capacity of the environment.
B. Yes, humans will turn increasing quantities of land to agriculture.
C. No, a population of organisms cannot continue to grow forever.
D. No, humans are already stopping their population growth.

(C)

36. What was the approximate size of the world's human population in the year 0, the year of change from B.C. to A.D.?

A. 100 million
B. 200 million
C. 300 million
D. 400 million

(B)

37. Which projected growth pattern corresponds to the present rate of human population growth?

A. I
B. II
C. III
D. IV

(A)

38. Which projected growth pattern represents the future occurrence of widespread famine or some other human tragedy?

A. I
B. II
C. III
D. IV

(D)

39. Which projected growth pattern represents a beginning of individual consciousness about population growth?

A. I
B. II
C. III
D. IV

(B)

40. Which projected growth pattern represents the possibility of a future policy of no further population growth?

A. I
B. II
C. III
D. IV

(C)

---

41. Population fluctuations that are very regular in their occurrence are called population:

A. cycles.
B. explosions.
C. models.
D. peaks.

(20.8, A)

The next eight items refer to the reading selections that follow. Each italicized portion, preceded by a number, is an item. Read the entire selection first, then go back and key each item as follows:

(20.8, AI)

KEY: A. problem (stated or implied)
B. hypothesis (possible solution to the problem)
C. statement of observations

"[42] Every 3 to 5 years, lemmings march for miles, scarcely stopping to eat or rest. Eventually they eliminate themselves by plunging into lakes, rivers, and fjords, where they drown. [43] What causes them to do this has long been a mystery. [44] In 1963, the Swedish hordes of lemmings moved south. [45] At a certain road in their path, 44 of them crossed per minute. Although there was food along the route, when one of the lemmings died, it was eaten by the others. Contrary to what one might expect, these marching lemmings were healthy, mature young—born the previous spring. [46] Did the population reach the limit of the food supply in its home environment? [47] These mass movements often occur in years when there is no food shortage."

"About every ten years, the snowshoe hares of North America die of unknown causes. Examination of the corpses shows [48] they are neither undernourished nor diseased. However, they suddenly go into convulsions and die. Meadow voles of New York State show almost identical behavior. [49] Is it possible that increased disorganization causes a fatal state of physical exhaustion?"

____ 42. (C)
____ 43. (A)
____ 44. (C)
____ 45. (C)
____ 46. (B)
____ 47. (C)
____ 48. (C)
____ 49. (B)

The next six items concern an awareness of assumptions when they are made.

(inv. 20.3, AI)

A lady presents a clerk with a closed bag she has filled. She says, "These oranges are $1.20 per kilogram." The clerk places the bag, unopened, on the scale and announces, "That will be $1.80, please." The lady pays and leaves the store with the bag.

Use this key to answer the following:

KEY: A. an assumption made by the lady
B. an assumption made by the clerk
C. an assumption made by both the lady and the clerk
D. not an assumption

____ 50. The scale is in good working order and accurate:

(C)

____ 51. Oranges are in the bag:

(B)

____ 52. The clerk read the scale correctly:

(A)

____ 53. The clerk calculated the cost correctly:

(A)

____ 54. The other person is honest:

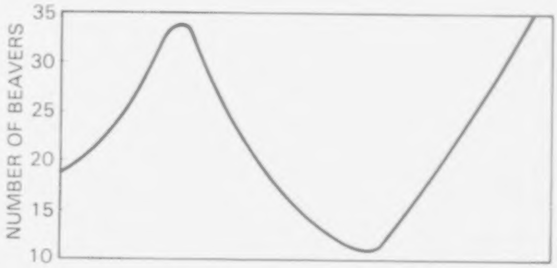
(C)

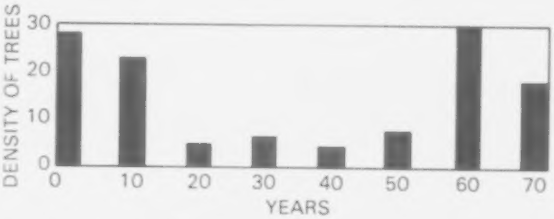
____ 55. The oranges were grown on trees:

(D)

The next three items are based on a long-term study of a beaver population and the density of trees on which these beavers feed.

(inv. 20.3, AI)





56. Peaks and dips in tree density appear to:

A. follow peaks and dips in numbers of beavers.
B. have no relation to numbers of beavers.
C. occur with no apparent pattern.
D. precede peaks and dips in numbers of beavers.

(D)

57. The decline of the beaver population between the 20th and the 45th years is probably related to:

A. abiotic factors.
B. disease.
C. drought.
D. food scarcity.

(D)

58. The number of beavers, approaching 40 individuals at the end of the study, cannot be expected to continue increasing because:

A. beavers are hunted for their pelts.
B. data suggest beavers do not form colonies.
C. density of the trees is falling at the end of the study.
D. other streams and lakes may not exist nearby.

(C)

The next three items are based on a population of field mice in a 50-hectare cornfield. (1 km² = 100 hectares.)

(inv. 20.3, AI)

Year	Population of field mice
1935	12
1940	38
1945	76
1950	119
1955	129
1960	115
1965	83
1970	112
1975	109
1980	110

59. What was the density per hectare of the field mice in 1950?

A. 119 per hectare
B. 23.8 per hectare
C. 11.9 per hectare
D. 2.38 per hectare

(D)

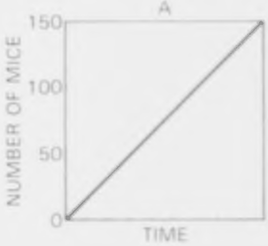
60. In whole numbers, what was the average annual increase in the numbers of mice from 1935 to 1950?

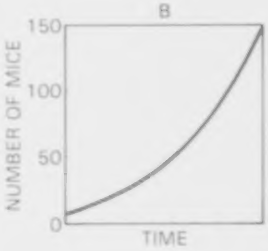
A. 3 per year
B. 7 per year
C. 12 per year
D. 35 per year

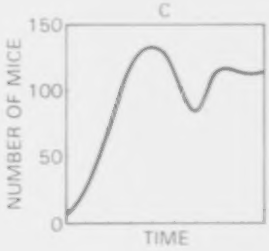
(B)

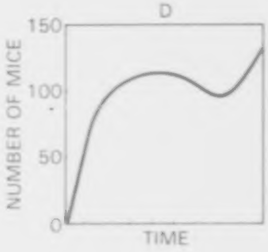
61. Which of the following graphs best shows the data for the population of mice?

(C)









62. How is tolerance to environmental factors related to the geographic range of organisms? Tolerances:

A. are not related to geographic ranges.
B. are the result of geographic ranges.
C. completely explain geographic ranges.
D. do not entirely explain geographic ranges.

(20.9, D)

63. How is dispersal related to a species' geographic range? Dispersal:

A. always expands a geographic range.
B. can help extend a geographic range.
C. changes a geographic range by itself.
D. is not related to geographic range.

(20.10, B)

64. Which can prevent dispersal of organisms?

A. all of the following
B. behavior of the organisms
C. ecological requirements of the organisms
D. geography of the organism's range

(20.11, A)

65. Why are polar bears not found in the Antarctic?

A. all of the following
B. They cannot survive in the tropics.
C. They cannot walk or swim very far.
D. They do not have any food in the Antarctic.

(20.11, C)

66. Which probably has the most rapid dispersal?

A. a fungus whose spores are carried by the wind
B. a plant whose fruit is eaten by squirrels
C. a protist who swims by cilia
D. an animal who lives in a swamp and runs on all four legs

(20.11, A)

67. Barriers to dispersal:

A. may be behavioral.
B. may be ecological.
C. may be physical or geographical.
D. all of the above

(20.11, D)

68. An example of a barrier to dispersal of many species is:

A. their biome.
B. day/night changes.
C. mass migration.
D. mountain ranges.

(20.11, D)

The next twelve items refer to dispersal of animals on four oceanic islands. The islands have the same climate and are about equal distance from each other. Use the key to evaluate the items.

(20.11, AI)

LOCATION OF ANIMALS			
 ISLAND I	 ISLAND II	 ISLAND III	 ISLAND IV
Small bird	Small bird	Small bird	Small bird
Lizard	Lizard	Lizard	Lizard
Small mammal	Small mammal	No small mammals	No small mammals
Freshwater fish	No freshwater fish	No freshwater fish	No freshwater fish
96 other species of animals	47 other species of animals	13 other species of animals	39 other species of animals

KEY: A. logical hypothesis, based on data
B. restatement of data
C. statement refuted by data
D. statement neither supported nor refuted by data

____ 69. The direction of migration of these animals is from west to east:

(A)

____ 70. Salt water is a barrier to the freshwater fish:

(A)

____ 71. Freshwater fish are present only on Island I:

(B)

____ 72. There are fewer species of animals on Island III than on Island IV:

(B)

____ 73. The small mammal was probably on Island II before the freshwater fish was on Island I:

(D)

____ 74. The migration has been orderly, without any examples of skipping over an island to the next:

(C)

____ 75. Though the islands have the same climate, Island III may have some rock or mineral to which certain plants or animals have limited tolerance:

(A)

____ 76. The lizard species, if it disappears, will disappear first from Island I:

(D)

____ 77. Larger islands, or a mainland area, probably lie to the west of these islands:

(A)

____ 78. Probably the islands have established plant populations:

(A)

____ 79. If there are few or no plants on any island, kelp or other producer organisms must wash in regularly from the ocean:

(A)

____ 80. The least successful species in crossing the sea barrier has been the small mammal:

(C)

---

81. A climax community is considered permanent in terms of:

A. human intervention.
B. long-term climatic changes.
C. natural disasters.
D. naturally-occurring successions.

(20.13, D)

82. How do primary and secondary succession of terrestrial communities differ?

A. Primary begins in a disturbed area, secondary begins with bare rock or soil.
B. Primary begins with bare rock or soil, secondary begins in a disturbed area.
C. Secondary succession follows primary.
D. They do not differ.

(20.13, B)

The next 13 items refer to the economically valuable coniferous forest of the Pacific Northwest. Douglas fir, cedar, and hemlock are the principal trees of the region. Several of their characteristics follow:

(20.1–20.14, inv. 20.4; AI)

Characteristics	
Douglas Fir	**Cedar and Hemlock**
Seedlings die in shade. Seedlings grow well on ashes.	Seedlings grow in shade. Seedlings do not grow well on ashes.
Seeds are winged.	Seeds are not winged.

83. When old Douglas firs die in dense forests, they probably will be succeeded by:

A. Douglas fir seedlings.
B. cedar seedlings only.
C. cedar and hemlock seedlings.
D. hemlock seedlings only.

(C)

84. The effect of a fire in this area would be to increase the numbers of:

A. Douglas firs.
B. cedars.
C. hemlocks.
D. pines.

(A)

85. In the logging industry, cutting most trees in selected areas (clearcutting), and cutting only the oldest trees in other areas, will tend to:

A. eliminate Douglas firs.
B. eliminate cedars and hemlocks.
C. encourage seedlings of Douglas firs only.
D. encourage seedlings of all three kinds of trees.

(D)

Use the key as you continue with the next items.

KEY: A. logical hypothesis, based on data
B. restatement of data
C. statement refuted by data
D. statement neither supported nor refuted by data

____ 86. The climax forest in this area is a Douglas fir forest:

(C)

____ 87. Since all three kinds of trees lived in the area preceding human occupation, natural fires must have occurred from time to time:

(A)

____ 88. In time, cedar trees will come to outnumber hemlocks:

(D)

____ 89. Burned-over areas will receive new Douglas fir seeds from the nearest stands of firs:

(A)

____ 90. A volcanic eruption and its fallout will favor new growth of cedars and hemlocks:

(C)

____ 91. Several other species of trees grow in this coniferous forest:

(D)

____ 92. Douglas fir seeds are winged, cedar and hemlock seeds wingless:

(B)

____ 93. Prevention of logging, combined with fire prevention, would favor elimination of Douglas firs:

(A)

____ 94. Cedar and hemlock seedlings grow well in shade:

(B)

____ 95. The climate of this coniferous forest is cool and moist:

(D)

---

96. Which determines what kinds of animals live in a community? The:

A. abiotic factors
B. plants
C. plants and abiotic factors
D. animals themselves

(20.14, C)

97. If a North American grassland became a great deal warmer and drier over 100 years, what would probably happen?

A. The grassland organisms would gradually be replaced by migrating desert organisms.
B. The grassland organisms would gradually be replaced by other grassland organisms.
C. The grassland organisms would rapidly evolve into desert organisms.
D. Nothing, because the organisms would adapt.

(20.14, C)

98. Which is evidence that early (prehistoric) humans were interested in ecology or natural history?

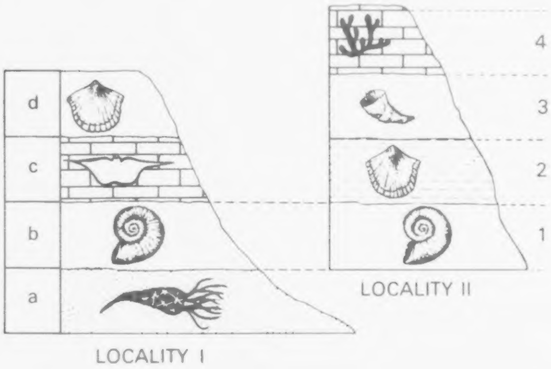
A. all of the following
B. Cave paintings of animals
C. The discovery of stone tools
D. The finding of animal bones near human fossils

(20.15, B)

Chapter 21
Ecosystems of the Past

The next eight items refer to the following diagrams of sedimentary rocks from two neighboring states in the United States. The letters a through d and the numbers 1 through 4 refer to the different strata of rocks. All the fossils shown are marine. Fossils of the same organisms are of approximately the same age.

(21.1, AI)



1. The oldest rock stratum from the two localities appears to be:

   A. a.
   B. 1.
   C. b.
   D. 4.

   (A)

2. The same stratum in the two localities is represented by:

   A. a and 1.
   B. b and 1.
   C. d and 3.
   D. d and 4.

   (B)

3. Two strata that appear to vary in composition but that are of approximately the same age are:

   A. a and 1.
   B. b and 4.
   C. c and 3.
   D. d and 2.

   (D)

4. The most recent stratum from the two localities is:

   A. c.
   B. 3.
   C. d.
   D. 4.

   (D)

5. Two strata that are in Locality I, but appear to be missing from Locality II are:

   A. a and b.
   B. a and c.
   C. b and c.
   D. b and d.

   (B)

6. A possible explanation for why Strata 3 and 4 are not found in Locality I is that they have:

   A. been under water at Locality I.
   B. eroded from Locality I.
   C. formed Stratum c in Locality I.
   D. not yet formed at Locality I.

   (B)

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7. Stratum c may have existed at one time in Locality II but later have been:

   A. covered and dissolved by the waters of more recent oceans.
   B. destroyed by the weight of Strata 2, 3, and 4.
   C. excavated during mining operations by human industries.
   D. uplifted and eroded before the ocean floor subsided again.

   (D)

8. If the two sets of strata are related as the preceding questions indicate, then it is possible for biologists to determine from them the:

   A. ancestors of all the fossils.
   B. depth of the former ocean waters.
   C. relative ages of all the fossils.
   D. time when the ocean disappeared.

   (C)

---

9. Which is the most reliable and accurate method of determining the age of rocks?

   A. Find how deep the rocks are.
   B. Follow layers of rocks to where they are exposed.
   C. Measure the ration of radioactive elements to their breakdown products.
   D. Observe what kind of fossils are in the rocks.

   (21.1, C)

10. In the geologic time scale, the largest time divisions are named:

    A. ages.
    B. epochs.
    C. eras.
    D. periods.

    (21.1, C)

11. A fossil is defined as any:

    A. extinct species.
    B. evidence of former life.
    C. petrified rock.
    D. sedimentary stratum.

    (21.1, B)

12. Uranium-lead dating of fossil-bearing rocks is based on the time required for:

    A. radioactive lead to produce uranium.
    B. rock layers to be deposited as sediments.
    C. sediments to change into rock.
    D. uranium to break down into lead.

    (21.1, D)

13. One layer of fossil-bearing sedimentary rock may be thicker than another. To judge that one of the two ages of life lasted longer than the other, a biologist would have to assume that both layers of sediments were:

    A. byproducts of living activity.
    B. laid down at the same rate.
    C. made up of the same limestone.
    D. unrelated to surface earth erosion.

    (21.1, B)

14. Uranium (^{235}U) has a half-life of 4.5 billion years. Paleontologists find fossils in a layer below rocks that contain three parts uranium to 1 part lead. How old are the fossils?

    A. about 4.5 billion years
    B. older than 2 billion years
    C. younger than 2 billion years
    D. We cannot tell.

    (21.1, C)

15. Scientists who study fossil remains and identify extinct organisms are called:

    A. geologists.
    B. meteorologists.
    C. paleontologists.
    D. pathologists.

    (21.1, C)

16. Most fossils of extinct organisms are preserved impressions of:

    A. body structures.
    B. ecological niches.
    C. food webs.
    D. habitats.

    (21.1, A)

17. Reconstructing the way of life of an extinct organism is partly based on comparing its fossils to:

A. inorganic sediments.
B. living organisms.
C. minerals of the same age.
D. traces of decomposers.

(21.2, B)

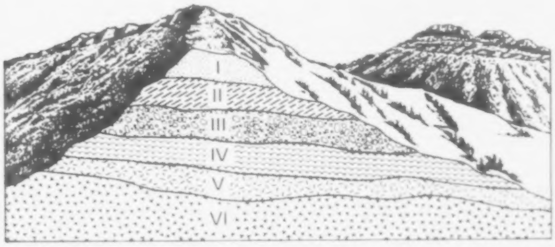
18. Creatures such as dinosaurs and flying reptiles would be considered improbable except for:

A. buried coal deposits.
B. early human records.
C. fossil body parts.
D. radioactive dating methods.

(21.2, C)

The next three items refer to the following drawing of a hillside excavated for a new highway.

(21.2, AI)



19. The six strata of rock show no evidence of disturbance or disarrangement by earth movements. Geologists therefore assume that the oldest stratum is:

A. I.
B. III.
C. IV.
D. VI.

(D)

20. Stratum III is coal. Stratum IV contains fossil starfish and shark's teeth. These two items of information suggest to biologists that the environment changed in a past geologic age from:

A. freshwater to marine.
B. marine to freshwater.
C. marine to terrestrial.
D. terrestrial to freshwater.

(C)

21. To search for fossils of terrestrial organisms in the exposed hillside, biologists would examine:

A. each stratum.
B. lower strata.
C. lower and middle strata.
D. middle and upper strata.

(D)

---

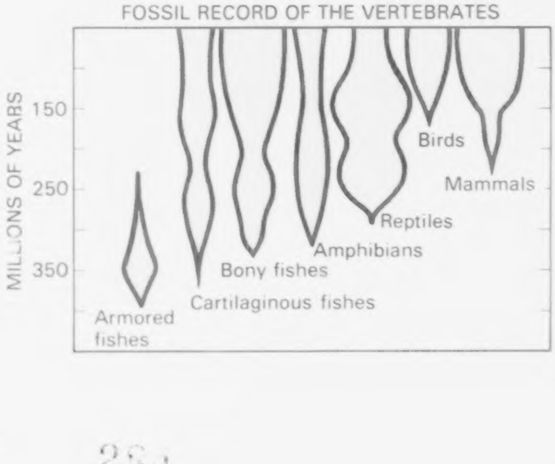
22. Much about how dinosaurs lived and died is still speculation partly because there are no:

A. closely related living organisms for comparison.
B. fossilized eggs or offspring for study.
C. fossilized foods that could have supported dinosaurs.
D. well-preserved complete dinosaur skeletons.

(21.3, A)

The next four items are based on the following diagram.

(21.4, AI)



23. Which animals are extinct?

A. amphibians
B. armored fishes
C. cartilaginous fishes
D. reptiles

(B)

24. Which animals evolved most recently?

A. armored fishes
B. birds
C. bony fishes
D. mammals

(B)

25. Which two groups of vertebrates have the most living species?

A. birds and mammals
B. bony and cartilaginous fishes
C. bony fishes and mammals
D. reptiles and birds

(C)

26. Based on the data, which of the following hypotheses seems most reasonable?

A. Armored fishes evolved from cartilaginous fishes.
B. Cartilaginous fishes evolved from bony fishes.
C. Mammals evolved from birds.
D. Reptiles evolved from amphibians.

(D)

---

27. Two organisms that have different appearances and ways of life but share the same ancestors are said to show:

A. adaptive convergence.
B. adaptive radiation.
C. continuous distribution.
D. discontinuous distribution.

(21.4, B)

28. Two organisms that have similar appearances and ways of life but are descendants of different ancestors are said to show:

A. adaptive convergence.
B. adaptive radiation.
C. continuous distribution.
D. discontinuous distribution.

(21.4, A)

29. Which is evidence for plate tectonics?

A. all of the following
B. The continents are all made up of the same materials.
C. The rocks in the continents are the same age.
D. There are great cracks in the ocean floor that are getting wider.

(21.6, D)

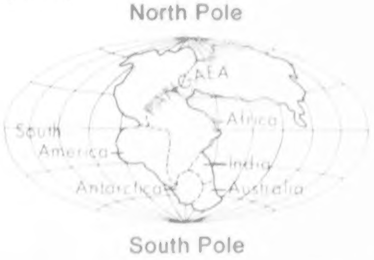
30. The theory that a single supercontinent broke up to form today's scattered continents is called the theory of:

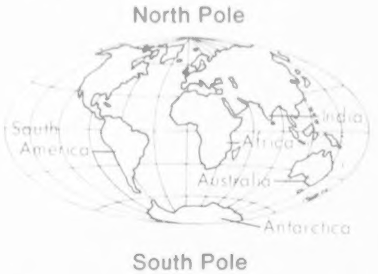
A. discontinuous distribution.
B. large land masses.
C. paleontology.
D. plate tectonics.

(21.6, D)

The next three items are based on the following maps.

(21.6)





31. The two maps, taken together, illustrate:

A. adaptive radiation.
B. adaptive convergence.
C. continental drift.
D. population distributions.

(C)

32. The theory that the earth's lands and ocean floors are divided into moving segments of the earth's crust is called the theory of:

A. discontinuous distribution.
B. evolution.
C. paleontology.
D. plate tectonics.

(D)

33. The physical separation of the continents, along with climatic differences and other factors, suggests why early species came to have:

A. adaptive convergence.
B. discontinuous distribution.
C. relatively few fossils.
D. similar origins.

(B)

---

34. The distributions of extinct and living species of organisms have been greatly affected by:

A. aging of species.
B. continental drift.
C. ocean size.
D. sedimentation.

(21.7, B)

35. The major difference between paleoecosystems and other ecosystems is that all or most of the species of a paleoecosystem are:

A. aquatic or amphibian.
B. decomposers.
C. extinct.
D. protistlike.

(21.7, C)

The next eight items refer to the following information and chart.

(21.6–21.7; AI)

The land bridge between North and South America did not exist during part of the early history of mammals. The families of mammals on each continent were isolated. However, Atlantic and Pacific fishes were not isolated.

By the times indicated on the chart, the land bridge had been re-established.

Families of Mammals			
Millions of years ago	**North America**	**Common to North and South America**	**South America**
1	22 families	22 families	22 families
12	25 families	2 families	27 families

Use the following key to answer these eight items.

KEY: A. reasonable interpretation of the data
B. restatement of the data
C. interpretation contrary to the data
D. statement unrelated to the data

____ 36. Considerable migration of mammals took place between North and South America during the 11 million years covered by the chart:

(A)

____ 37. More families of mammals existed in North and South America 12 million years ago than 1 million years ago:

(B)

____ 38. Dinosaurs existed in North America but were rare in South America:

(D)

____ 39. Isolation of the fishes in the Atlantic and Pacific Oceans contributed to the isolation of the mammals in North and South America:

(C)

____ 40. Following the migrations of mammals between the two continents, competition may have caused many families to become extinct:

(A)

____ 41. The two families of mammals that were common to North and South America 12 million years ago may have originated on one continent and migrated to the other:

(A)

____ 42. Mammals replaced reptiles as the dominant vertebrates in South America earlier than in North America:

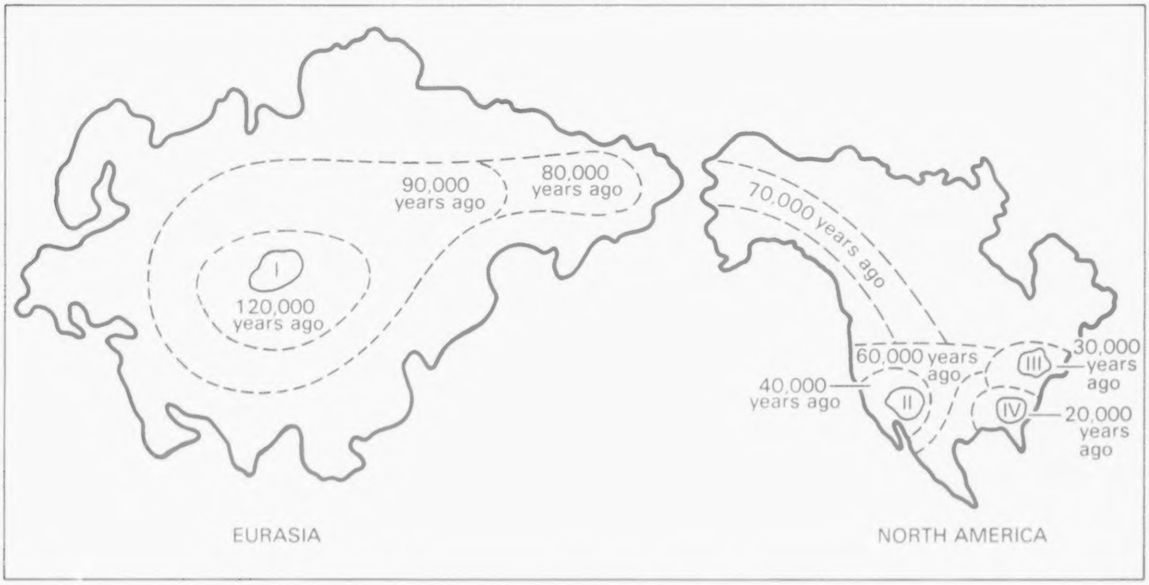
(D)

____ 43. Biologists might predict that the variety in ocean fishes increased as the variety in mammals decreased:

(A)

The next ten items are based on the following map. The small areas enclosed by solid lines show four living populations (I, II, III, and IV) of Species X. The larger areas enclosed by broken lines of dashes show approximate ages of fossils of Species X that have been found.

(21.6–21.7, AI)


90,000 years ago
80,000 years ago
I
120,000 years ago
70,000 years ago
60,000 years ago
40,000 years ago
II
III
30,000 years ago
IV
20,000 years ago
EURASIA
NORTH AMERICA

44. From the fossil and living evidence it appears that Species X originated in:

    A. central Eurasia.
    B. eastern Eurasia.
    C. eastern North America.
    D. western North America.

(A)

45. The distribution of Species X today can be described as:

    A. continuous.
    B. convergent.
    C. discontinuous.
    D. increasing.

(C)

46. Species X apparently appeared in North America as a result of:

A. adaptive convergence.
B. adaptive radiation.
C. continental drift.
D. prehistoric migration.

(D)

47. The area occupied by Species X has:

A. decreased, then increased, with time.
B. increased, then decreased, with time.
C. increased relatively constantly with time.
D. remained about the same through time.

(B)

48. The most significant fact about the distribution of Species X is that this species has apparently spread from:

A. east to west in Eurasia.
B. east to west in North America.
C. Eurasia to North America.
D. North America to Eurasia.

(C)

49. Fossil distribution alone could not have revealed the origin and direction of spread of Species X. This information depended on:

A. numbers of fossils found in each location.
B. radioactive dating of the fossils.
C. sizes of surviving populations.
D. weather patterns of the last 100,000 years.

(B)

50. Which two populations of Species X were probably separated most recently?

A. I and II
B. II and III
C. II and IV
D. III and IV

(D)

51. Which two populations have been isolated longest?

A. I and II
B. I and IV
C. II and III
D. II and IV

(B)

52. What is the minimum number of populations that existed 120,000 years ago?

A. 1
B. 2
C. 3
D. 4

(A)

53. What is the probable number of populations that existed 20,000 years ago?

A. 1
B. 2
C. 3
D. 4

(D)

---

54. The theory that life began in the waters of the earth has been supported by the fact that the oldest fossils discovered are fossils of:

A. amphibious organisms.
B. fresh-water organisms.
C. lowland or swamp organisms.
D. marine organisms.

(21.8, D)

55. The hypothesis that life began in the waters of the earth became a theory as soon as it was shown that:

A. all Cambrian fossils are marine.
B. land surfaces were unbroken rock.
C. land temperatures were abnormally high.
D. plants preceded animals in origin.

(21.8, A)

56. Coal-age forests of unfamiliar trees demonstrate that many organisms today and in the past have occupied the same:

A. communities.
B. ecological niches.
C. ecosystems.
D. forest populations.

(21.10, B)

57. Coal deposits in Greenland and Antarctica bear evidence that these ice-covered land masses were once in a:

A. Cambrian seabed.
B. current of coastal water.
C. different place or climate.
D. high-altitude land environment.

(21.10, C)

For the next four items match the following geological periods with the organisms that would have lived back then.

(21.8–21.11)

KEY: A. Cambrian
B. Carboniferous
C. Devonian
D. Triassic

____ 58. Fishes dominated the seas, amphibians appeared, first vascular plants evolved:

(C)

____ 59. Only marine organisms; no chordates present, but all major invertebrate phyla represented; brachiopods and arthropods dominant:

(A)

____ 60. Large dinosaurs dominant; large areas dry and mountainous; flowering plants appeared:

(D)

____ 61. Large tree-like ferns; club mosses and horse tails; climate warm and humid; many insects; amphibians the only large land animals:

(B)

Use the key below to identify the animal phylum to which each of the next ten items refer.

(21.1–21.12)

KEY: A. Arthropoda
B. Chordata
C. Coelenterata
D. Mollusca

____ 62. Which phylum has the most abundant fossils from Cambrian times?

(A)

____ 63. Which phylum has no fossils from Cambrian times?

(B)

____ 64. To which phylum did the dinosaurs belong?

(B)

____ 65. Which phylum has left layers of seashells from past ages?

(D)

____ 66. Which phylum would be predicted to leave fossils of the fewest numbers of species?

(C)

____ 67. To which phylum did the trilobites that populated ancient oceans belong?

(A)

____ 68. Which phylum has produced the largest animals?

(B)

____ 69. Which phylum has produced the greatest number of species?

(A)(14.7)

____ 70. To which phylum do the fossil corals of hundreds of millions of years of ocean life belong?

(C)(14.4)

____ 71. Which phylum has produced its major groups of animals most recently in geologic time?

(B)

72. Which is characteristic of the Cenozoic Era?

A. all of the following
B. Dinosaurs were abundant.
C. Humans were plentiful and widespread.
D. Mammals were widespread and dominant.

(21.12, D)

73. Which is characteristic of primates?

A. all of the following
B. color vision
C. foreward facing eyes
D. nails rather than claws

(21.13, A)

74. Which is *not* characteristic of most primates?

A. front facing eyes and color vision
B. only 2 mammary glands and single offspring at a time
C. solitary and learning by instinct
D. well-developed, sensitive digits with nails

(21.13, C)

75. Primates differ from most other mammals in having:

A. body parts free of hair.
B. both eyes directed forward.
C. no tail or tail vertebrae.
D. shorter forelimbs than hindlimbs.

(21.13, B)

76. Most families of primates differ from the hominid family in being:

A. arboreal.
B. four-limbed.
C. omniverous.
D. social.

(21.13, A)

77. Hominids are a group of fossil and living primates differing from other primates by having:

A. grasping hands.
B. one pair of mammary glands.
C. oral communication.
D. upright posture.

(21.14, D)

78. Like humans today, *Australopithecus africanus* are known from fossil evidence to have:

A. buried their dead.
B. used fire.
C. used speech.
D. walked upright.

(21.15, D)

79. Scientists whose work is the study of human fossils and human cultures are called:

A. anthropologists.
B. paleontologists.
C. psychologists.
D. zoologists.

(21.15, A)

80. The family Hominidae consists of fossil and living primates that differ from other primates in having:

A. body parts free of hair.
B. one pair of mammary glands.
C. three-dimensional vision.
D. upright posture.

(21.15D)

81. The oldest known fossil hominids have been unearthed in Africa by the Walker expedition. Radioactive dating places their age at approximately:

A. 25,000 years ago.
B. 250,000 years ago.
C. 2,500,000 years ago.
D. 25,000,000 years ago.

(21.15, C)

The next 16 items are based on the classification of hominids. Use the key to answer the items.

(21.13–21.15)

KEY: A. a characteristic of mammals
B. a characteristic of primates, but not most other mammals
C. a characteristic of hominids, but not other primates
D. a characteristic of humans, but not other hominids

Every characteristic fits A, but to answer an item correctly you must make the most precise classification possible.

____ 82. communication using sounds:

(A)

____ 83. upright posture:

(C)

____ 84. three-dimensional vision:

(B)

____ 85. care of the young:

(A)

____ 86. communication using symbols:

(D)

____ 87. four limbs:

(A)

____ 88. grasping hands:

(B)

____ 89. one pair of mammary glands:

(B)

____ 90. burial of dead:

(D)

____ 91. internal development of offspring:

(A)

____ 92. offspring in litters:

(A)

____ 93. offspring single or as twins:

(B)

____ 94. use of objects as tools:

(B)

____ 95. improvement of objects as tools:

(C)

____ 96. use of tended fires:

(D)

____ 97. hair:

(A)

---

98. How many living species of hominids are classified in the family Hominidae?

A. 1
B. 2
C. 3
D. 4

(21.15, A)

99. Individuals of the fossil genus *Australopithecus* are classified as:

A. apes.
B. hominids.
C. humans.
D. monkeys.

(21.15, B)

100. *A. africanus* and *A. robustus* both had:

A. cave-wall art.
B. primitive agriculture.
C. skin tents.
D. stone tools.

(21.15, D)

101. From fossil skulls, scientists can reconstruct:

A. brain size and probable intelligence.
B. facial and scalp hair.
C. skin color and texture.
D. whether tools were made and used.

(inv. 21.3, A)

102. The foramen magnum of a skull is the:

A. bony ridge above the eye sockets.
B. hole through which the nostrils emerge.
C. hole through which the spinal cord connects with the brain.
D. region of each temple to which the cheekbone is anchored.

(inv. 21.3, C)

103. By studying the position of the foramen magnum in a fossil primate skull, scientists can obtain evidence about whether the extinct primate:

A. carried its head upright.
B. had bushy eyebrows.
C. had modern cheek structure.
D. relied on its sense of smell.

(inv. 21.3, A)

104. To determine whether a fossil primate walked upright, scientists rely mainly on studying the:

A. opposable digits and sternum.
B. scapulas and vertebrae.
C. sternum and scapulas.
D. vertebrae, pelvis, and leg bones.

(inv. 21.3, D)

The next nine items are based on the following fossil primate discoveries.

(21.13–21.16, inv. 21.3; AI)

Skeleton number	Cranial capacity	Other skull characteristics	Axial skeleton	Appendicular skeleton	Artifacts found with skeleton
1	540 cm^3	Bony ridges over eye sockets; prominent jaw	Fused vertebrae in small of back; heavy pelvis	Arms longer than legs; femurs heavy-boned	None
2	630 cm^3	Bony ridges over eye sockets; prominent bony ridge on top of skull running from front to back; prominent jaw	Articulated vertebrae in small of back; pelvis missing	Arms shorter than legs; hands missing; femurs slender	Broken stones
3	760 cm^3	Bony ridges over eye sockets; no prominent ridge on top of skull; facial bones missing; moderately prominent jaw	Articulated vertebrae in small of back; pelvis partly missing, but with one hip socket intact indicating upright stance	Arms shorter than legs; femurs slender; hands spatulate	Chipped stones; charcoal in pit
4	770 cm^3	Bony ridges over eye sockets; no prominent ridge on top of skull; prominent jaw	Articulated vertebrae in small of back; pelvis intact indicating upright stance	Arms shorter than legs; femurs slender; hands spatulate	Chipped stones
5	1250 cm^3	Reduced ridges over eye sockets; no ridge on top of skull; reduced jaw; cheekbones slender and closely spaced	Missing	Missing	Fragment of flaked stone blade
6	900 cm^3	Bony ridges over eye sockets; no prominent ridge on top of skull; cheekbones wide; moderately prominent jaw	Articulated vertebrae in small of back; pelvis intact indicating upright stance	Most of both arms missing; femurs slender	Chipped stones; flaked stones; carved design on cave wall

105. How many hominids appear to be represented by these fossils?

A. 2
B. 3
C. 4
D. 5

(D)

106. How many humans appear to be represented by these fossils?

A. 2
B. 3
C. 4
D. 5

(B)

107. How many pongids appear to be represented by these fossils?

A. 1
B. 2
C. 3
D. 4

(A)

108. A hominid that had a brain larger than the brain of one of the humans is represented by Skeleton Number:

A. 2.
B. 3.
C. 4.
D. 6.

(C)

109. From the skull data, the hominid of the preceding question appears to have been an individual of the species:

A. *Australopithecus africanus.*
B. *Australopithecus robustus.*
C. *Homo erectus.*
D. *Homo habilis*

(A)

110. Which of the following artifacts found with the fossils is most likely to be associated with both humans and other hominids?

A. carved design on cave wall
B. charcoal in pit
C. chipped stones
D. fragment of flaked stone blade

(C)

111. Which individuals appear to be members of the genus *Australopithecus?*

A. 1 and 2
B. 2 and 3
C. 2 and 4
D. 3 and 4

(C)

112. What may be the most important question scientists raise about Skull 5?

A. How tall might this individual have been?
B. How can it be determined whether the individual was male or female?
C. Did scavengers chew and scatter the bones of the rest of the skeleton at the time the individual died?
D. Did the flaked blade belong to the individual, or was it the cause of death?

(D)

113. What further data would be *most* useful in helping you review your interpretations of the fossils?

A. geographical areas where the fossils were found
B. names of the discoverers of the fossils
C. nature of the sedimentary strata in which the fossils were found
D. radioactive datings showing approximate ages

(D)

114. The earliest definitely established human species has been named:

A. Cro-Magnons.
B. *Homo erectus.*
C. *Homo sapiens.*
D. Neanderthals.

(21.16, B)

115. Which of the following characteristics is unique to humans as reflected by study of the fossil record?

A. seeing three-dimensionally
B. using fire
C. using tools
D. walking upright

(21.16, B)

116. Varieties are recognized in the human species today because:

A. facial features differ.
B. family relationships differ.
C. gene frequencies differ.
D. languages differ.

(21.18, C)

117. All living humans are considered one species because they:

A. bear strong resemblances to one another.
B. belong to closely related cultures.
C. can communicate in abstract symbols.
D. can interbreed and produce fertile offspring.

(21.18, D)

The next eight items refer to the gene frequencies of four alleles in three populations.

(inv. 21.4, AI)

Allele	Frequencies		
	Population I	Population II	Population III
L^a	0.9	0.5	0.6
L^b	0.0	0.3	0.1
L^c	0.1	0.2	0.3
p^a	0.5	0.3	0.4

118. Alleles L^a, L^b, and L^c are:

A. linked.
B. multiple alleles.
C. polygenes.
D. X-linked.

(B)

119. How many loci are represented for the four alleles shown in the table?

A. 1
B. 2
C. 3
D. 4

(B)

For the first five of the next six items use the following key.

KEY: A. Populations I and II
B. Populations I and III
C. Populations II and III

____ 120. If measured by allele L^a, which populations would be the greatest biological distance apart?

(A)

____ 121. If measured by allele L^b, which populations would be the greatest biological distance apart?

(A)

____ 122. If measured by allele L^c, which populations would be the greatest biological distance apart?

(B)

____ 123. If measured by allele P^a, which populations would be the greatest biological distance apart?

(A)

____ 124. On the basis of all the data, which populations would be the greatest biological distance apart?

(A)

125. If allele L^b was a mutant, which population was closest to the source of the mutation?

A. I
B. either I or III
C. II
D. III

(C)

---

126. Evidence that isolated gene pools undergo change can be inferred from an observation about varieties in the human species. In all historic accounts of the past 2000 years, different varieties of humans were found to be correlated with their:

A. geographical locations.
B. stage of civilization.
C. successful interbreeding.
D. town or village patterns.

(inv. 21.4, A)

127. Which of the following probably would contribute to genetic drift in a human population?

A. interbreeding with other populations
B. location near other human populations
C. low mutation rates
D. small population size

(inv. 21.4, D)

The next eight items relate to the arrival and early influence of human beings in America. Some authorities believe humans settled the American continents as long ago as 50,000 years. Others believe the date was somewhat more recent.

(21.7–21.19, AI)

128. If the first humans arrived in America 50,000 years ago, they probably were

A. *Australopithecus.*
B. *Homo erectus.*
C. *Pithecanthropus.*
D. *Homo sapiens.*

(D)

For the next seven items use the following information and key.

Until about 11,000 years ago horses, camels, mastodons mammoths, and giant ground sloths lived in North America. A current hypothesis is that the extinction of these animals was due to the arrival of humans.

KEY: A. true and supports the hypothesis.
B. true but contradicts the hypothesis.
C. true but unrelated to the hypothesis.
D. false.

____ 129. The niche that humans occupied when they arrived was previously unoccupied:

(C)

____ 130. The gene pool of present-day American Indians may be more closely related to the gene pool of the early humans:

(C)

____ 131. There was probably an overkill of easy prey such as ground sloths:

(A)

____ 132. Fossil records indicate that horses were plentiful in America until 12,000 years ago:

(A)

____ 133. The first humans to arrive in America were primarily hunters:

(A)

____ 134. When any population of animals enters a favorable new habitat, there usually is a population explosion:

(A)

____ 135. Probably all the kinds of animals named died of some disease brought in by humans:

(D)

Chapter 22
Biomes Around the World

1. Why is radiant energy important to an ecosystem?

   A. all of the following
   B. It affects the temperature.
   C. It determines the topography.
   D. It determines wind direction.

   (22.1, B)

2. Which abiotic factor determines the climate of an ecosystem?

   A. all of the following
   B. precipitation and humidity
   C. radiant energy
   D. temperature

   (22.1, A)

3. A climatogram is a:

   A. graph summarizing daily sunlight and temperature.
   B. graph summarizing monthly temperature and precipitation measurements for an area.
   C. map showing altitude, annual precipitation and average temperature.
   D. telegram sent to a meterologist.

   (22.1, B)

4. Why are day lengths not the same throughout the year towards the poles?

   A. all of the following
   B. The earth's axis is tilted.
   C. The earth is *not* a sphere.
   D. The earth rotates as it moves around the sun.

   (22.1, B)

5. A biome is usually named for its:

   A. animals.
   B. climate.
   C. plants.
   D. soil.

   (22.1, C)

6. The factor that determines the boundaries of a biome is the:

   A. characteristic plants.
   B. climate.
   C. climax communities.
   D. physical barriers.

   (22.1, B)

7. All organisms around the world that live in the same climate share the same:

   A. biome.
   B. community.
   C. ecosystem.
   D. population.

   (22.1, A)

8. Biomes are distinguished by their:

   A. animals.
   B. climate.
   C. decomposers.
   D. plants.

   (22.1, B)

9. A biome consists of all the organisms that share a particular:

   A. area.
   B. climate.
   C. ecosystem.
   D. succession.

   (22.1, B)

For the next seven items match the biomes with the descriptions.

(22.2–22.5)

KEY: A. mid-latitude deciduous forest
B. taiga
C. tropical rain forest
D. tundra

____ 10. Very short growing season; 24 hr sunlight in summer; shallow ponds and marshes; permafrost; cold, long winters with little sunlight, light snow and high winds:

(D)

____ 11. Trees with broad leaves that fall each autumn; four distinct seasons; long summer days with much radiant energy; precipitation high (50–125 cm/yr):

(A)

____ 12. Migratory birds and mammals, such as geese and caribou; many small burrowing animals such as lemmings; vegetation dominated by grasses, sedges, lichens and mosses; few short woody plants; great swarms of certain insects:

(D)

____ 13. Sun nearly overhead throughout year; day lengths, temperature, humidity, and amount of light energy constant; rainfall very high (2 m/yr); soil poor:

(C)

____ 14. Trees mainly evergreen conifers; many browsing animals such as deer and moose; many animals, such as bears; hibernate in winter; many insects and insect eating birds:

(B)

____ 15. Extends in a broad band across Northern Europe, Asia and North America, winters cold and days short; considerable snowfall that stays; many lakes, ponds and bogs:

(B)

____ 16. Many different kinds of trees arranged in layers; epiphytes and vines abundant as are arboreal animals; little leaf litter on ground:

(C)

---

17. Which of the following lists biomes in order from warmest to coolest in climate?

    A. mid-latitude rain forest, tropical deciduous forest, coniferous forest, tundra
    B. mid-latitude deciduous forest, tropical rain forest, coniferous forest, tundra
    C. tropical deciduous forest, coniferous forest, mid-latitude rain forest, tundra
    D. tropical rain forest, mid-latitude deciduous forest, coniferous forest, tundra

(22.2–22.5, D)

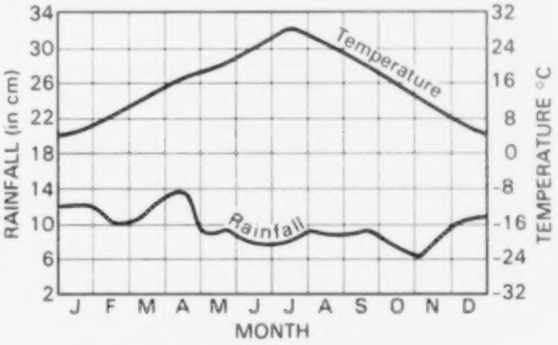
18. Which of the following lists biomes in order from most to least radiant energy received?

    A. coniferous forest, deciduous forest, savanna, tundra
    B. deciduous forest, savanna, coniferous forest, tundra
    C. savanna, deciduous forest, coniferous forest, tundra
    D. tundra, savanna, deciduous forest, coniferous forest

(22.2–22.5, C)

The next three items refer to the following climatogram.

(22.2–22.5, AI)



19. The biome indicated by the climatogram is probably:

    A. coniferous forest.
    B. mid-latitude deciduous forest.
    C. tropical rain forest.
    D. tundra.

(B)

20. The evidence that the biome has "seasons" of the year is suggested mostly by:

A. latitude.
B. months.
C. rainfall.
D. temperature.

(D)

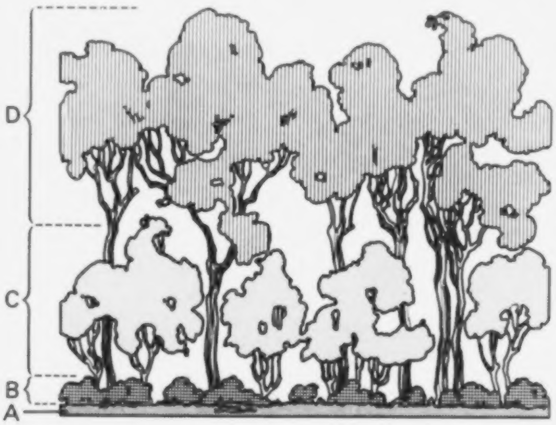
21. If an example of the biome occurs in Central or North America, its principal plants may be:

A. beeches, maples, oaks, and shrubs.
B. cedars, firs, spruce, and junipers.
C. lichens, mosses, miniature willows, and miniature birches.
D. buttress-supported tall trees of many species, epiphytes, and vines.

(A)

The next seven items are based on the following diagram of a forest. Use the letters on the left to answer the first five of the seven items.

(22.4–22.5, AI)



____ 22. Where is most of the photosynthesis occurring?

(D)

____ 23. In which layer would a slight decrease in light be most critical for the plants?

(B)

____ 24. Where would most annual herbs be found?

(B)

____ 25. Where would most fungi be found?

(A)

____ 26. Which layer provides most clues to whether the forest is a climax forest or a stage in succession?

(C)

27. The existence of this forest suggests that the limiting factor of the biome is probably:

A. moisture.
B. radiant energy.
C. temperature extremes.
D. wind.

(C)

28. If the trees shown are deciduous, then this type of forest might be found in central:

A. Africa.
B. Australia.
C. Canada.
D. Europe.

(D)

---

29. Most food production in a forest takes place in the:

A. canopy.
B. epiphytes.
C. undergrowth.
D. vines.

(22.4–22.5, A)

30. Why is there very little buildup of organic material on the floor of a tropical rain forest?

A. all of the following
B. The trees don't lose their leaves all at once.
C. The leaves are rapidly broken down by insects, fungi and bacteria.
D. The climate is warm, moist and constant.

(22.5, A)

31. Arboreal animals live in:
   - A. burrows.
   - B. snow.
   - C. swamps.
   - D. trees.

   (22.5, D)

32. An epiphyte's adaptations provide it with:
   - A. access to soil water.
   - B. access to sunlight.
   - C. resistance to humidity.
   - D. resistance to wind.

   (22.5, B)

33. Which of the following lists biomes in order from wettest to dryest?
   - A. deciduous forest, rain forest, grassland, desert
   - B. desert, grassland, deciduous forest, rain forest
   - C. grassland, deciduous forest, rain forest, desert
   - D. rain forest, deciduous forest, grassland, desert

   (22.2–22.6, D)

34. How are grasslands and deciduous forests in North America related to moisture and why?
   - A. Deciduous forests are found in dry, cold areas and wet, warm areas because the trees lose their leaves.
   - B. Deciduous forests are found in dryer areas because trees can tolerate drought.
   - C. Grasslands are found in dry, cold areas and wet, warm areas because grass grow best in the cold.
   - D. Grasslands are found in dryer areas because grasses can tolerate drought.

   (22.6, D)

35. Estivation and hibernation increase the duration of tolerance to:
   - A. cold and snow.
   - B. heat and drought.
   - C. optimum conditions.
   - D. unfavorable conditions.

   (22.5–22.7, D)

36. The dormant state of certain animals through a hot, dry season is called:
   - A. estivation.
   - B. dehydration.
   - C. germination.
   - D. hibernation.

   (22.7, A)

The next four items are based on the following chart.

(22.2–22.7, AI)

Location	Annual precipitation (in cm)	Pattern of annual precipitation	Average annual temperature °C
A	110	Regular	22
B	65	Periodic drought	22
C	15	One rainy season	30
D	15	Regular	−10

____ 37. The location that is most likely to be tundra is:

(D)

____ 38. The location that is most likely to be grassland is:

(B)

____ 39. The location that is most likely to be deciduous forest is:

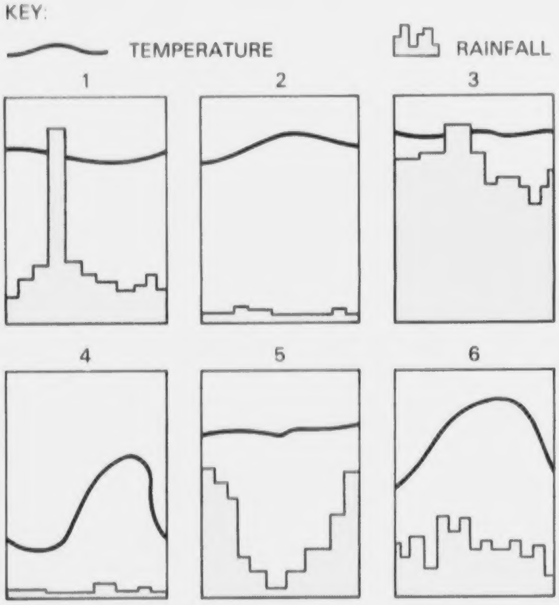
(A)

____ 40. The location that is most likely to be desert is:

(C)

The next four items refer to the following climatograms. A year's temperature and rainfall pattern are indicated on each climatogram.

(22.2–22.8, AI)



41. Which represents tundra?

A. 1
B. 2
C. 4
D. 5

(C)

42. Which represents desert?

A. 2
B. 3
C. 4
D. 5

(A)

43. Which represents tropical rain forest?

A. 1
B. 3
C. 5
D. 6

(B)

44. A mid-latitude biome, either grassland or forest, is suggested by climatogram:

A. 1.
B. 3.
C. 4.
D. 6.

(D)

For the next four items match the method of adapting to desert conditions with the descriptions or examples.

(22.8)

KEY: A. drought endurers
B. drought escapers
C. drought evaders
D. drought resistors

____ 45. cactus plants with leaves modified to spines:

(D)

____ 46. mesquite plants with long (25–30m) tap roots:

(C)

____ 47. small annuals that grow rapidly from seeds with seed coats that are hard or have germination inhibitors:

(B)

____ 48. creosote bushes with small, wax covered leaves and extensive shallow roots that put out chemicals that inhibit the growth of other plants:

(A)

---

49. Tall grasslands with scattered trees in tropical dry areas, home of large hoofed browsing and grazing mammals and large predators describes a:

A. chapparal.
B. desert.
C. savanna.
D. tropical deciduous forest.

(22.10, C)

50. Moisture is the limiting factor in a:

A. climatogram.
B. forest.
C. savanna.
D. swamp.

(22.10, C)

51. In which of the following biomes is annual precipitation greatest?

A. mid-latitude deciduous forest
B. mid-latitude grassland
C. savanna
D. tundra

(22.2–22.10, A)

52. The coolest of the following biomes is a:

A. coniferous forest.
B. rain forest.
C. savanna.
D. tundra.

(22.2–22.10, D)

53. The wettest of the following mid-latitude biomes is a:

A. chaparral.
B. deciduous forest.
C. desert.
D. grassland.

(22.4–22.11, B)

For the next four items, match the biomes with the descriptions.

(22.6–22.11)

KEY: A. chaparral
B. desert
C. grassland
D. tropical deciduous forest

____ 54. Herbivores include insects, small mammals such as prairie dogs, and large, hoofed, grazing mammals such as bison and antelope. Plants herbaceous; many grow from base instead of tips:

(C)

____ 55. Evaporation often exceeds low precipitation; rains usually heavy but brief. Day and night temperatures in air and at soil surface differ drastically:

(B)

____ 56. Wet and dry seasons; trees lose their leaves in dry season. Temperatures uniform year round:

(D)

____ 57. Rain falls in winter; soil thin and has low fertility; large shrubs with thick underground stems and roots; rodents and reptiles numerous:

(A)

58. Cool summers, mild winters; abundant precipitation (up to 640 cm/yr); tall conifers; abundant ferns, mosses and lichens; elk and deer; many insects, small invertebrates, and rodents; and seed eating birds describes a:

A. chapparal.
B. coastal coniferous forest.
C. mild latitude deciduous forest.
D. taiga.

(22.13, B)

59. A climax community is considered permanent in terms of:

A. human intervention.
B. long-term climatic changes.
C. natural disasters.
D. naturally-occurring successions.

(22.13, D)

60. Human activities are most likely to affect a biome's:

A. climate.
B. latitude.
C. seasons.
D. successions.

(22.14, D)

61. Today the most important biotic factor affecting organisms and where they live is:

A. climax communities.
B. human land use.
C. lifespan.
D. natural barriers.

(22.14, B)

62. A change in climate and overgrazing by domestic animals have resulted in:

A. acid rain.
B. desertification.
C. eutrophication.
D. natural succession.

(22.16, B)

63. Which human activities have affected biomes?

A. all of the following
B. removal of trees
C. overgrazing
D. burning of coal and other fossil fuels

(22.17, A)

Chapter 23
Aquatic Ecosystems

1. Organisms that live in water are called:
   - A. aquatic.
   - B. buoyant.
   - C. motile.
   - D. terrestrial.

   (23.1, A)

2. All the waters of the earth are a part of the:
   - A. atmosphere.
   - B. littoral zone.
   - C. hydrosphere.
   - D. marine environment.

   (23.1, C)

3. Everyday observers distinguish lakes from ponds by their expanse of surface water. Ecologists use as a guide whether:
   - A. dissolved minerals are present.
   - B. light penetrates to the bottom.
   - C. phytoplankton live in the water.
   - D. wave action occurs at the surface.

   (23.2, B)

4. Most, but not all, phytoplankton are:
   - A. freshwater.
   - B. macroscopic.
   - C. many-celled.
   - D. microscopic.

   (23.2, D)

5. Where would you expect to find the most plankton in a given surface area of water?
   - A. an established pond
   - B. a flowing river
   - C. a mountain brook
   - D. the open ocean

   (23.2, 23.5, A)

6. Freshwater and marine zooplankton consist of both:
   - A. bacteria and fungi.
   - B. carnivores and herbivores.
   - C. fungi and algae.
   - D. producers and consumers.

   (23.2, B)

7. Plankton are divided into phytoplankton and zooplankton on the basis of whether they are:
   - A. carnivores or herbivores.
   - B. decomposers or scavengers.
   - C. parasites or free-living.
   - D. producers or consumers.

   (23.2, D)

8. Zooplankton include:
   - A. bacteria and protists.
   - B. bacteria and small animals.
   - C. protists and small animals.
   - D. protists and small plants.

   (23.2, C)

9. Which is true about ponds and lakes?
   - A. Their boundaries are quite distinct unlike terrestrial ecosystems.
   - B. Their boundaries with terrestrial ecosystems are indistinct.
   - C. Their food chains are complex and involve only microscopic aquatic organisms.
   - D. Their food chains are simple and involve macroscopic organisms only.

   (23.2, B)

The next five items refer to five bodies (I–V) of fresh water with approximately equal surface areas. They vary in locality and in depth, as shown in the table that follows.

(23.3, AI)

Depth (in meters)	Equator	Mid-latitude	Arctic
10	I		IV
100		III	
1,000	II		V

10. Which bodies of water would be most likely to have plants growing on the bottom?

A. I and III
B. II and III
C. III and V
D. IV and V

(A)

11. Which would a biologist predict to have few or no plants on the bottom?

A. I and II
B. II and III
C. III and IV
D. II and V

(D)

12. Which bodies of water would have the most even distribution of dissolved nutrients?

A. I, II, and III
B. I, II, and IV
C. II, III, and IV
D. III, IV, and V

(D)

13. Which body of water would a biologist predict to have the most anaerobic organisms?

A. I
B. II
C. IV
D. V

(B)

14. Which bodies of water would have the most even distribution of dissolved oxygen?

A. I and II
B. II and V
C. III and IV
D. IV and V

(C)

15. A limiting factor to the depth at which producer-consumer communities exist in lakes and oceans is:

A. carbon dioxide.
B. food.
C. light.
D. minerals.

(23.3, 23.10, C)

16. Ecologists distinguish ponds from lakes primarily by the water's:

A. clearness.
B. depth.
C. surface expanse.
D. temperature.

(23.3, B)

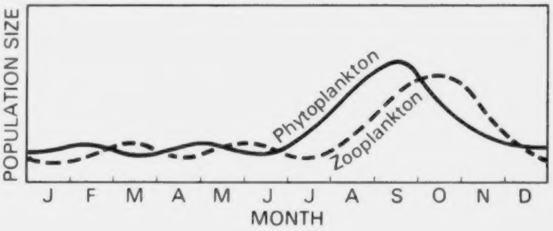
17. Most of the productivity of a lake or pond is carried on by its:

A. decomposers.
B. emergent plants.
C. floating plants.
D. phytoplankton.

(23.3, D)

The next 15 items relate to data plotted on the following graph. The graph shows the population sizes of phytoplankton and zooplankton in a deep lake in the northern United States.

(23.3, AI)



Use the key to identify the statements.

KEY: A. reasonable interpretation of the data
B. statement contradicted by the data
C. restatement of the data
D. reasonable statement not covered by the data

____ 18. Growth in the phytoplankton population is related to the months in which sunlight and temperature are most appropriate:

(A)

____ 19. Growth in the zooplankton population is related to growth in the phytoplankton population:

(A)

____ 20. The zooplankton include both herbivores and carnivores:

(D)

____ 21. The populations of phytoplankton and zooplankton fluctuate during the year:

(C)

____ 22. The winter turnover of water in the lake causes rapid increase in the number of zooplankton:

(B)

____ 23. Some of the phytoplankton are larger than some of the zooplankton:

(D)

____ 24. The peak of the curve for zooplankton is lower than the peak for phytoplankton:

(C)

____ 25. The phytoplankton are producers for the zooplankton:

(A)

____ 26. A deficiency in dissolved nutrients causes low production by the phytoplankton:

(D)

____ 27. There is no productivity in the lake during the winter:

(B)

____ 28. The winter turnover of water in the lake causes an increase in the dissolved nutrients in surface waters:

(D)

____ 29. The numbers of phytoplankton increase only slightly during the winter months of January and February:

(C)

____ 30. The fact that numbers of phytoplankton do not increase significantly during the winter turnover of water is probably a consequence of low temperatures and low-intensity winter sunlight:

(D)

____ 31. This lake is located in Northern Virginia:

(B)

____ 32. The lowest level of the zooplankton population occurs in January:

(C)

---

33. What is the ultimate fate of lakes? They will:
    A. gradually become deeper and bigger.
    B. gradually fill in and change to terrestrial ecosystems.
    C. rapidly become more complex and change to a salt-water ecosystems.
    D. rapidly become smaller and less productive.

(23.3, B)

34. Where does most of the photosynthesis occur in a lake? In the:

A. bottom where the submerged rooted plants are
B. middle layer where the zooplankton are
C. top where the floating lillies and emergent cattails are
D. upper layer where the phytoplankton are

(23.3, D)

35. The existence of aquatic consumers in a lake is limited by:

A. light.
B. minerals.
C. oxygen.
D. temperature.

(23.3, C)

36. A thermocline is a:

A. graph showing the light penetration in a lake.
B. graph showing the temperatures at different depths in a lake.
C. layer of cold water sandwiched between two layers of warm water.
D. zone between a top warm layer of water and lower cooler layer, in which the temperature and 0_2 drop rapidly.

(23.4, D)

37. There are no aerobic animals living near the bottom in tropical lakes because the:

A. animals cannot swim that deep.
B. light does not reach that deep.
C. pressure is too great at those depths.
D. upper and lower layers of water do not mix so oxygen and minerals are lacking.

(23.4, D)

38. A thermocline:

A. prevents the movement of plankton in a lake.
B. prevents vertical mixing of upper and lower layers of water in a lake.
C. is a graphic record of water temperatures at different levels in a lake.
D. is a stagnant layer of cold water lying over a warm layer in a lake.

(23.4, B)

39. Ponds and lakes with no outlets receive runoff water from rain, but lose water only by evaporation. This means that they tend to become enriched with:

A. fresh water.
B. littoral life.
C. minerals.
D. oxygen.

(23.4, C)

40. Compared to terrestrial environments, a limiting factor in consumer life in lake and ocean depths is:

A. minerals.
B. organic wastes.
C. oxygen.
D. temperature.

(23.4, C)

41. Winter benefits consumers in deep waters of lakes by cooling the surface water until it sinks to the bottom with its:

A. dissolved oxygen.
B. dissolved sewage.
C. surface fishes.
D. surface scum.

(23.4, A)

42. In which of these aquatic environments would a biologist expect to find the most dissolved oxygen per volume of water?

A. a rapidly flowing brook
B. a slowly moving river
C. the still waters of a lake
D. the waters in mid-ocean

(23.6, A)

For the next three items, match the different flowing water ecosystems with their descriptions.

(23.5–23.7)

KEY: A. brooks
B. rivers
C. streams

____ 43. Very slow moving; fine sediment deposited; channel widens to form deltas or swamps; many rooted plants and phytoplankton:

(B)

____ 44. Usually cool; rapidly moving, with lots of oxygen; no plankton; few attached producers:

(A)

____ 45. Moderately slow moving; large material sediments; some phytoplankton and rooted plants:

(C)

46. Compared to terrestrial environments, aquatic environments are more stable in:
    - A. numbers of species.
    - B. producer-consumer distribution.
    - C. sunlight absorbed.
    - D. temperature range.

(23.9, D)

47. Which of these environments shows least change in its daily and seasonal temperatures?
    - A. desert
    - B. ocean
    - C. tropics
    - D. tundra

(23.9, B)

48. The most important decomposers in both aquatic and terrestrial environments are:
    - A. annelid and nematode worms.
    - B. bacteria and fungi.
    - C. nitrogen-fixing algae.
    - D. parasites and scavengers.

(23.9, B)

49. Light absorption occurs nearest the surface in water that is:
    - A. clear.
    - B. cloudy.
    - C. moving.
    - D. still.

(23.9, B)

50. The most stable life environment is:
    - A. fresh water.
    - B. land.
    - C. mountains.
    - D. oceans.

(23.9, D)

51. Which best describes the ocean environments? They are:
    - A. getting less and less saline.
    - B. getting more and more saline.
    - C. gradually filling up.
    - D. in a steady state.

(23.9, D)

52. Which is the most important function of upwellings in the oceans? They:
    - A. bring up cold water to cool the oceans.
    - B. bring up minerals from the depths.
    - C. change the ocean currents.
    - D. mix the plankton giving diversity to the oceans.

(23.10, B)

53. The surface waters of the open ocean are limited in their:

A. dissolved nutrients.
B. dissolved salts.
C. exposure to air.
D. exposure to sunlight.

(23.10, A)

54. Deep-water marine organisms that produce their own light are called:

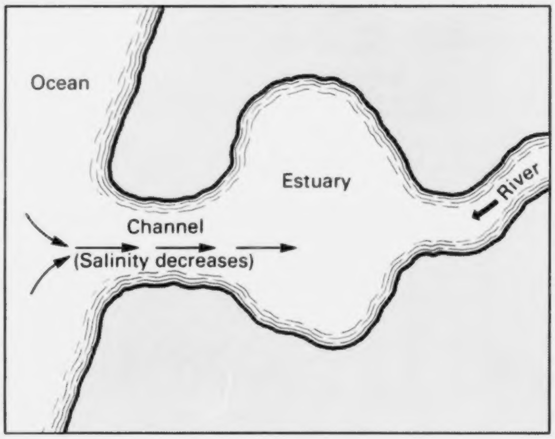
A. bioluminescent.
B. biosynthetic.
C. photoelectric.
D. photosynthetic.

(23.11, A)

For the next five items use the information, diagram, and table that follow.

(23.12, AI)

The salinity of the open ocean is about 3.5 percent. Some of the large rivers of the world do not enter the ocean directly. They open into tidal estuaries. Estuaries are passages where the ocean tide meets the river water. Chesapeake Bay and San Francisco Bay are examples of estuaries.



The following data on tolerance to salinity (salt concentration) refer to animals in a river, the estuary it empties into, and the channel from the estuary into the ocean.

Animal	Salinity tolerated
Gar (fish)	0.0–0.1%
Crab	0.1–3.5%
Snapper (fish)	3.5–3.6%
Oyster	0.5–3.0%
Shrimp	1.0–5.3%

55. The animal that would be found only in the river is the:

A. crab.
B. gar.
C. oyster.
D. snapper.

(B)

56. The animal that would be found only in the ocean is the:

A. crab.
B. gar.
C. oyster.
D. snapper.

(D)

57. The animal most likely to be found only in the estuary is the:

A. crab.
B. oyster.
C. shrimp.
D. snapper.

(B)

58. The shrimp might be a food source for:

A. the gar in the river.
B. other predatory river animals.
C. the snapper in estuary waters.
D. the snapper in the ocean.

(D)

59. Three of the animals appear to be at home in the waters of the estuary. Of these, the only one that cannot venture far into the ocean is the:

A. crab.
B. gar.
C. oyster.
D. shrimp.

(C)

---

60. Biotically, the chief value of the oceans to human beings is as a source of:

A. ecological competition.
B. food.
C. recreation.
D. waste-dumping sites.

(23.12, B)

61. Abiotically, the chief value of the oceans to human beings is as a source of:

A. minerals.
B. offshore oil.
C. rainfall.
D. salt water.

(23.12, C)

62. Aquatic organisms have relatively stable abiotic conditions in their environments. An exception is the organisms that live in the ocean's:

A. deep waters.
B. littoral zone.
C. mid-depths.
D. open surface waters.

(23.14, B)

The next 12 items are statements about marine environments. Use the key below to identify the indicated environments.

(23.10–23.14)

KEY: A. littoral zone
B. ocean depths
C. offshore waters
D. open surface waters

____ 63. Most of the organisms are dark in color, usually black or dark red:

(B)

____ 64. This environment is exposed to air twice a day:

(A)

____ 65. This environment, despite limited nutrients, is so great in expanse that most of the world's photosynthesis occurs in it:

(D)

____ 66. This environment is covered by water twice a day:

(A)

____ 67. The organisms in this environment have no enclosed air spaces or air-filled tissues in their bodies:

(B)

____ 68. Available nutrients would support more phytoplankton in this environment if the organisms would not be dashed to death on sand or rocks:

(A)

____ 69. Available nutrients support rich growths of phytoplankton in this environment:

(C)

____ 70. The only organisms in this environment are consumers:

(B)

____ 71. Light reaches the bottom in many but not all places in this environment, supporting populations of giant kelp and other seaweeds:

(C)

____ 72. The only producers in this environment are phytoplankton:

(D)

____ 73. Dissolved oxygen is lowest in this environment:

(B)

____ 74. The marine fishes and shellfish that people eat are in greatest abundance in this environment:

(C)

---

75. Which is a positive aspect of draining standing waters?

A. all of the following
B. Increasing the human food supply
C. Increasing migratory bird populations
D. Increasing the buildup of organic matter

(23.15, B)

76. Which is a positive outcome of dams?

A. all of the following
B. They cause the settling out of sediments and nutrients.
C. They may block movement of fish upstream to reproduce.
D. They may increase the amount of habitat for certain fish species.

(23.16, D)

The next three items are based on the disposal of sewage in streams and lakes, a common practice of human communities. Sewage consists mainly of discarded food remnants and human organic wastes. It usually is treated in one or more ways that partly decompose it before its release into streams and lakes.

(23.17)

77. As sewage enters a stream or lake, it enriches the water's supply of:

A. carbon dioxide.
B. dissolved nutrients.
C. inorganic minerals.
D. oxygen.

(B)

78. The enrichment of the stream or lake waters causes a rapid population increase of:

A. bottom-dwelling fishes.
B. emergent plants.
C. phytoplankton.
D. surface fishes.

(C)

79. As remaining sewage and overpopulated species clog the waters, decomposer populations grow. The decomposers use up the water's dissolved oxygen in breaking down organic wastes, with the result that:

A. aerobic conditions exist.
B. most of the fishes die.
C. minerals and nutrients decrease.
D. waters clear again.

(B)

---

80. Which is an outcome of acid rainfall into lakes?

A. all of the following
B. Reproduction and development of amphibians and fish is disrupted.
C. Species diversity declines.
D. Toxic metals are leached from the bottom.

(23.18, A)

81. Most pollution in ocean ecosystems results from:

A. direct interaction of the ocean with the atmosphere.
B. human activities on land.
C. human use of the ocean.
D. natural causes.

(23.19, B)

82. Mercury is a waste product of certain industries. It often is dumped into streams, rivers and oceans. Why is this a problem?

A. Mercury can be swallowed by animals, who become heavy and cannot move.
B. Mercury compounds can enter animals and damage their nervous systems.
C. Mercury molecules can float over the water surface and prevent evaporation.
D. It is not a problem. Mercury is insoluble in water.

(23.19, B)

83. Human wastes dumped into streams and rivers eventually:

A. are broken down by decomposers.
B. are converted to energy by consumers.
C. end up in the ocean.
D. recycle to land.

(23.19, C)

Chapter 24
Human-Shaped Ecosystems

1. Early humans, with few tools or weapons, fit into food webs as many other animals do, filling each role but that of:

   A. gatherers of plants.
   B. predators.
   C. prey.
   D. producers.

   (24.1, D)

2. No record exists of the first domesticated animals. The hypothesis today is that they were probably:

   A. cats.
   B. chickens.
   C. dogs.
   D. sheep.

   (24.1, C)

3. Humans began to shift from members to *makers* of biotic communities with the beginning of:

   A. agriculture.
   B. fishing.
   C. industry.
   D. world trade.

   (24.2, A)

4. No record exists of how agriculture arose. The favored hypothesis is that people conceived the idea from watching:

   A. birds scattering seeds.
   B. half-eaten plants taking root in garbage heaps.
   C. native grasses growing in almost pure stands.
   D. seeds germinating in gourds used for water.

   (24.2, B)

5. In excavations of early human settlements, extensive remains of domesticated animals are found:

   A. almost everywhere.
   B. only in agricultural settlements.
   C. only in fishing settlements.
   D. only in hunting settlements.

   (24.2, B)

6. Evidence from excavations shows that agriculture was at first carried on by hand. Little land was tilled by each farmer until:

   A. domesticated animals were hitched to plows.
   B. harvesting machines were invented.
   C. more land became available for agriculture.
   D. improved plant varieties were bred.

   (24.2, A)

7. Stored or surplus agricultural products made available to other people, especially tool makers and craftsmen, made division of labor possible and contributed to the rise of:

   A. large factories.
   B. rural government.
   C. taxes.
   D. towns and cities.

   (24.2, D)

8. The urban biome:

   A. increases water runoff after rains.
   B. is a natural ecosystem.
   C. is dependent upon climate.
   D. varies from location to location.

   (24.4, A)

9. Thinly scattered prehistoric people probably lived under conditions that promoted every type of health disorder except:

   A. contagious diseases.
   B. degenerative disorders.
   C. internal and external parasites.
   D. vector diseases.

   (24.5, A)

10. In a technological world, which of the following human problems causes or aggravates the other three?

    A. depletion of energy resources
    B. overpopulation
    C. pollution
    D. safe waste disposal

    (24.5, B)

11. Human activities in the biosphere usually involve trade-offs, or obtaining something that is wanted only at the cost of something else that is unwanted. A trade-off for being able to live in cities is:

    A. better-organized educational, health, and medical facilities.
    B. concentration of shopping and entertainment facilities.
    C. energy used in transporting food, fuel, other products, and wastes.
    D. loss of productivity from less-populated rural areas.

    (24.3–24.5, AI, C)

12. It has been estimated that beneath United States roads and highways alone, enough farmland lies to feed:

    A. 5,000 people.
    B. 50,000 people.
    C. 500,000 people.
    D. 5,000,000 people.

    (24.6, C)

13. Highways are necessary for human transportation. However, they also:

    A. affect world climate.
    B. encourage animal migrations.
    C. remove land from agricultural use.
    D. stop water runoff.

    (24.6, C)

14. What has been the most important force in the increase of suburbs in America?

    A. airlines and railroads
    B. modern construction techniques
    C. private automobiles
    D. public transportation

    (24.6, C)

15. As the human population has grown, the effect of changes made by people in the ecosystems surrounding them has been to:

    A. add to the number of species.
    B. improve the climate.
    C. leave the maximum number of ecosystems undisturbed.
    D. simplify the ecosystems.

    (24.7, D)

16. Which is an advantage of monoculture agriculture?

    A. all of the following
    B. Fungal and bacterial diseases can be easily controlled.
    C. It is economically profitable.
    D. It requires less moisture and minerals.

    (24.7, C)

17. Which best describes modern American agriculture?

    A. diverse
    B. energy efficient
    C. monoculture
    D. resource efficient

    (24.7, C)

18. Scientists improve crop food yields and the resistance of crops to disease. However, with increasing land use for homes, schools, shopping centers, and industries, the gain in crop yield per hectare will be overtaken by:

A. gain in crop yield with new pesticides.
B. loss of hectares from crop use.
C. lowered demand for more foods.
D. still more new improvements to crops.

(24.8, B)

19. A trade-off for having automobiles for individuals in place of scheduled public transportation is:

A. convenience in traveling when and where each individual chooses.
B. greatest air pollution than from any other cause.
C. higher employment in automobile and fuel industries.
D. lower accident and injury rate than in scheduled transportation.

(24.9, AI, B)

20. How can we lessen the impact of agriculture on the biosphere?

A. all of the following
B. Rotate and alternate crops.
C. Select crops for less irrigation.
D. Use organic instead of inorganic fertilizers.

(24.10, A)

21. What can we do to increase the amount of available food without harming the biosphere?

A. all of the following
B. Eat lower on the food chain.
C. Increase the use of pesticides.
D. Plant more monocultures on larger farms.

(24.10, B)

22. Which is the best policy towards nature to enable the ultimate survival of humans?

A. Coexist with nature by understanding and preserving it.
B. Immediately place all suitable land under cultivation and eliminate all consumers that compete with humans and their animals.
C. Maximize production with use of irrigation, pesticides, herbicides and inorganic fertilizers.
D. Remove all living things except humans and their cultivated crops and domesticated animals.

(24.11, A)

Chapter 25
Humankind in the Future

1. The human brain:
   - A. contains unique structures that no other mammal has.
   - B. has a cerebrum that is more expanded and folded than in most other mammals.
   - C. has a larger cerebellum and medulla than in most other mammals.
   - D. is larger than that of any other mammal.

   (25.1, B)

2. Human behavior is:
   - A. all innate.
   - B. all learned.
   - C. mainly inherited, with some learned.
   - D. mainly learned, with some inherited.

   (25.1, D)

3. Altruistic behavior is:
   - A. group behavior for the benefit of the individual.
   - B. innate behavior in which an individual acts selfishly.
   - C. learned behavior by birds, used to select a mate.
   - D. unselfish behavior in which an individual acts for the benefit of the population.

   (25.1, D)

4. Opponents claim sociobiology:
   - A. defends genetic determinism.
   - B. gives us a wrong view of biology that cannot be studied scientifically.
   - C. ignores the effect of genes and evolution.
   - D. is not based on biological principles.

   (25.2, A)

5. Sociobiologists believe:
   - A. all human behavior is innate.
   - B. all human behavior is learned.
   - C. human behavior is largely inherited, but can be modified by learning.
   - D. human behavior is mostly learned, with only some behavior inherited.

   (25.2, C)

6. Toxicity from pesticides, pollution, and other human-caused sources is slowly changing the environment. This means that not only human populations but populations of all organisms are being affected by new factors of:
   - A. emigration.
   - B. immigration.
   - C. natural selection.
   - D. population growth.

   (25.5, C)

7. Which best describes our past solution of environmental problems in the U.S.? We have:
   - A. ignored them all.
   - B. not had any problems.
   - C. slowed environmental damage with laws.
   - D. solved all our problems with laws.

   (25.5, C)

8. A technical solution to the population growth problem is modern birth-control methods. However, much of society does not feel that this solution is:
   - A. morally acceptable.
   - B. readily available.
   - C. usually effective.
   - D. widely known.

   (25.6, A)

9. The relationships among the problems of depletion of energy resources, population growth, pollution, and safe waste disposal reveal that the central problem of the four has contributed to:

   A. causing the other three.
   B. controlling the other three.
   C. reducing the other three.
   D. solving the other three.

   (25.6, A)

10. The U.S. 1984 birth rate was 1.8 for every 2 individuals yet our population is increasing. Why?

   A. all of the following
   B. Emigration is decreasing.
   C. Immigration is increasing.
   D. The number of individuals reproducing is increasing.

   (25.6, A)

11. All environmental issues:

   A. are connected to human population growth.
   B. are made up by extremists and are not important.
   C. can be solved by technology.
   D. can not be solved and should be ignored.

   (25.6, A)

12. The United States population is:

   A. decreasing because the birth rate has decreased.
   B. increasing because immigration is increasing.
   C. increasing because the birth rate had increased past the replacement level.
   D. stabilized because the decrease in birth rate equals the increase in immigration.

   (25.6, B)

13. Why were milk sales banned in Europe following the 1986 nuclear reactor accident in the western part of the Soviet Union?

   A. Most of the cows in Russia were killed and Europe's milk production was sent to help the Russians.
   B. Most of the milk comes from Russian cows which were radioactive.
   C. Radioactive particles blew over to Europe, fell out on grass eaten by cows, and made the milk radioactive.
   D. Radioactive particles got into Russian rivers which run through Europe. The European cows drank the river water, which contaminated their milk.

   (25.7, C)

14. Which environmental problem involves only one nation?

   A. acid rain
   B. hole in the ozone layer
   C. nuclear reactor accident (like that in Chernobyl)
   D. pollution of Clear Lake in Iowa

   (25.7, D)

15. What is nuclear winter?

   A. A cold winter that requires nuclear power to supply electricity for heating
   B. A winter that causes the nuclear family to stick together
   C. Extremely cold world-wide temperatures due to dust and smoke caused by nuclear war
   D. Warm world-wide winter temperatures due to atomic explosions

   (25.7, C)

16. One of the most promising lines of biological research is in "treating" human genes, or exchanging damaged or mutant genes for new ones. This field is called:

   A. bioengineering.
   B. gene suppression.
   C. genetic engineering.
   D. population genetics.

   (25.9, C)

17. Which is a successful example of genetic engineering?

    A. all of the following
    B. creation of a combination cow-bison by artificial insemination
    C. curing of sickle cell anemic persons by gene splicing
    d. production of human insulin by bacteria

    (25.9, D)

18. Which is a bioengineer least likely to make?

    A. artificial heart
    B. kidney dialysis machine
    C. new variety of beets producing more sugar
    D. plastic hip joint

    (25.9, C)

19. What is a potential danger of using bacteria such as *Pseudomonas fluorescens* as an insecticide?

    A. all of the following
    B. They may cause fatal human diseases.
    C. They may kill beneficial insects.
    D. They may kill the crops.

    (25.9, C)

20. Which best describes the evolution of the human brain? Its size has:

    A. decreased since *Homo sapiens* appeared.
    B. increased since *Homo sapiens* appeared.
    C. increased rapidly, then decreased since *Homo sapiens* appeared.
    D. stayed about the same since *Homo sapiens* appeared.

    (25.10, D)

21. Which limits the size of the human brain? The:

    A. development of culture
    B. number of nerve cells
    C. size of the birth canal
    D. strength of the vertebral column

    (25.10, C)

22. Which best describes environmental issues?

    A. Everyone agrees on problems and solutions.
    B. There is controversy over nearly all problems and solutions.
    C. They can be solved by technology.
    D. They must be solved by the governments.

    (25.11, B)

23. Problems facing humankind are:

    A. impossible to solve.
    B. simple and easy to solve.
    C. unique to specific populations, who must solve them.
    D. varied and complex, requiring knowledge and cooperation for solution.

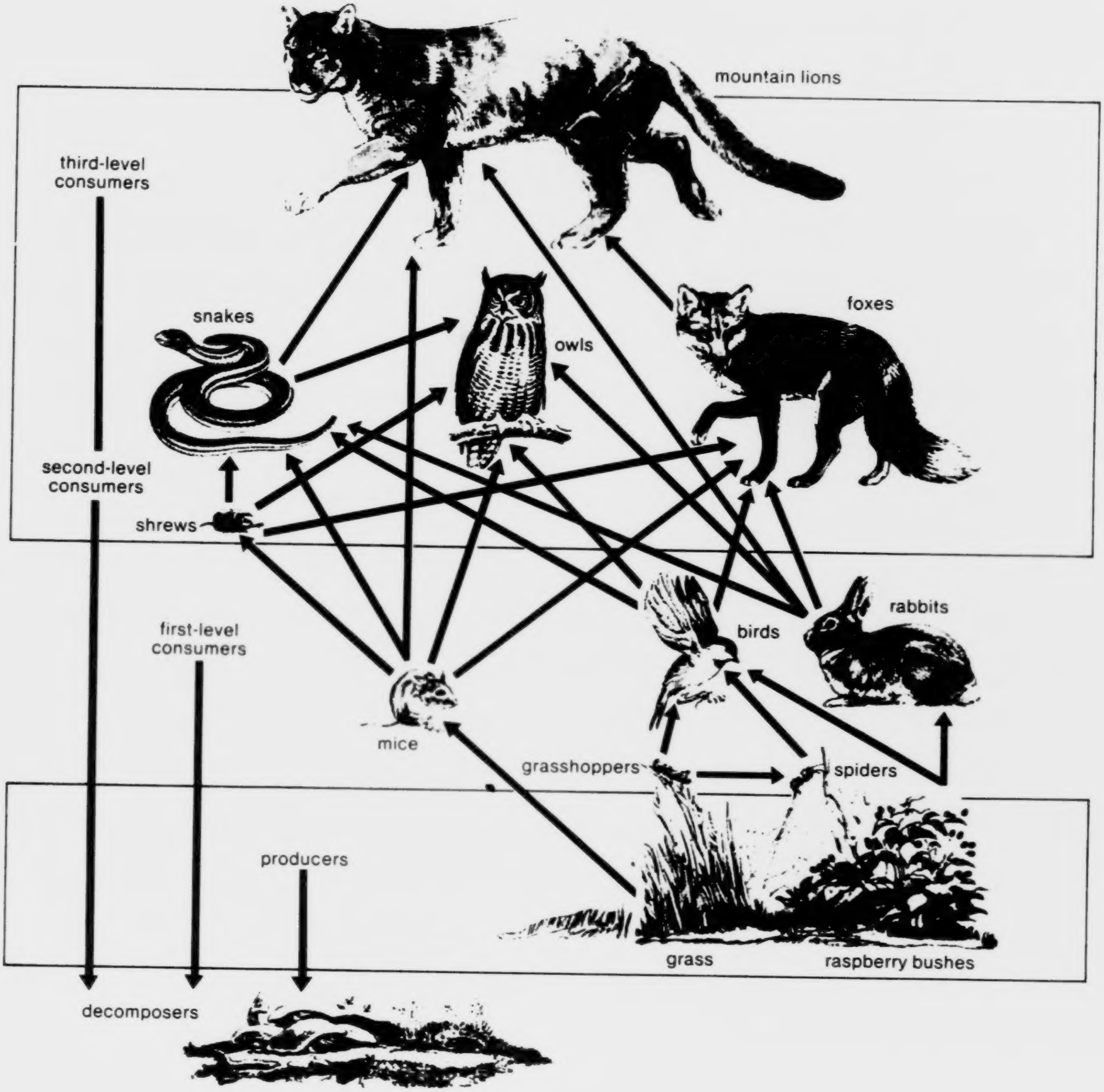
    (25.12, D)

List of Blackline Masters

List of Blackline Masters

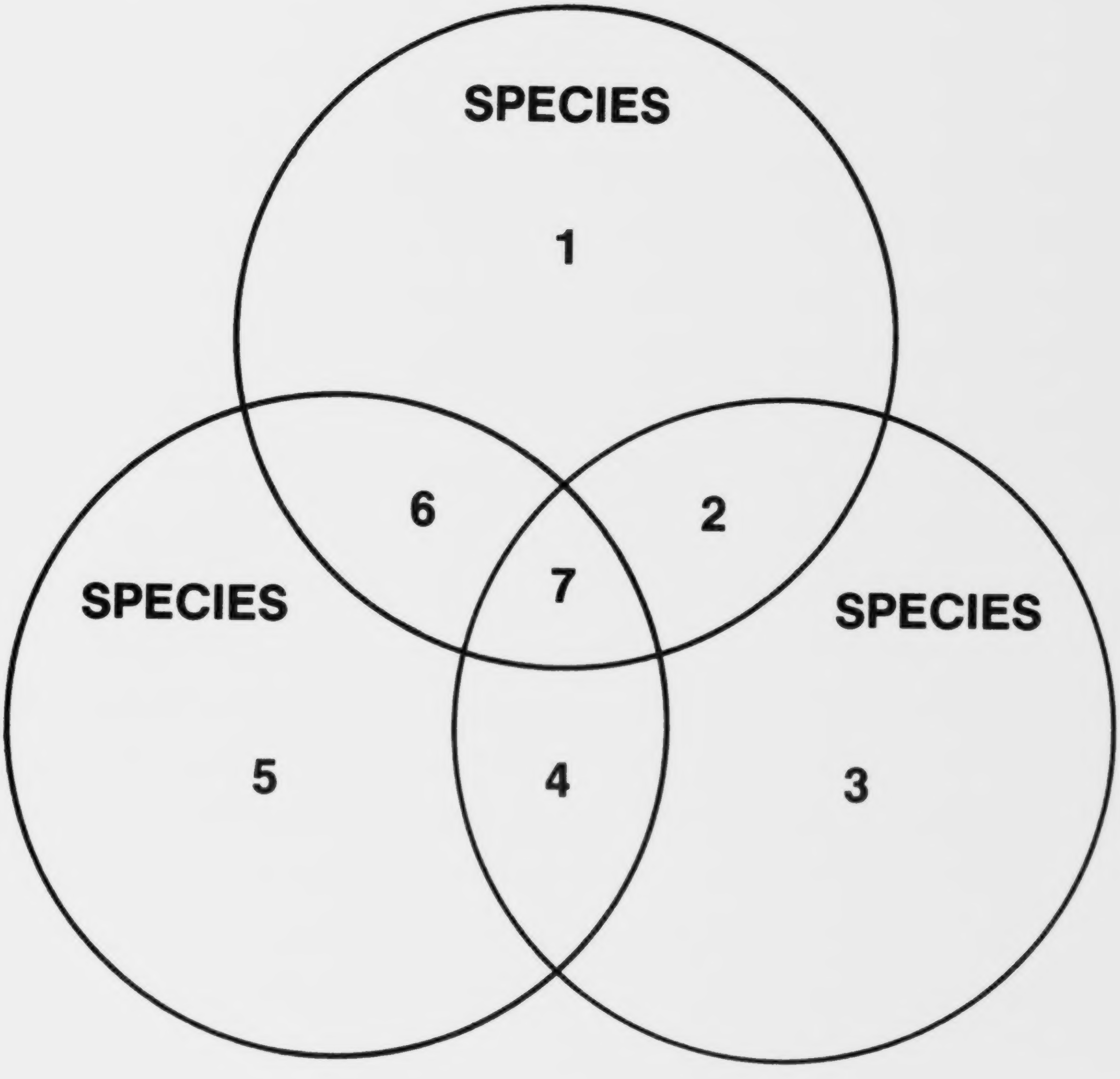
1. Food web
2. Relative humidity (Table for Investigation 3.1)
3. Overlap of species (for Investigation 3.1)
4. Models of hydrogen, carbon and oxygen
   Bonding to form sodium chorine
   Water molecule
   Ionization of water molecule
5. Formation of ATP
   ATP, ADP cycle
6. Carbon cycle
7. The formation of mono, di, and polysaccharides
8. The formation of fats from glycerol and fatty acids
9. The formation of a dipeptide from amino acids
10. The parts of a nucleotide master
    A chain of nucleotides
    Diagram of a portion of DNA
11. The cell cycle
12. Comparison of mitosis and meiosis
13. The hormonal changes in the female reproduction system
14. A dihybrid cross
15. The replication of DNA
16. The formation of mRNA
17. DNA determination of protein formation
18. Map of California and grid (for Investigation 9.4)
19. Metaphase smears and forms (for Investigation 8.3)
20. Metaphase smears and forms (additional)
21. Nitrogen cycle
22. Life cycle of *Chlamydomonas*
23. Geologic time scale of plants
24. Life cycle of mosses
25. Life cycle of flowering plants
26. Geologic time scale of animals
27. Hydra life cycle
28. Digestive system
29. Overall view of cellular respiration
30. Glycolosis
31. Krebs cycle
32. Electron transport system

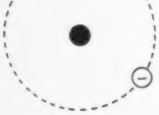
33. Respiratory and biosynthesis pathways
34. Heart action
35. Cells involved in the immune response
36. The activation of B cells
37. Macrophages and the destruction of virus-infected cells
38. The activation of T cells
39. Oxygen and carbondioxide transport
40. Automic nervous system
41. Endocrine glands
42. Regulation of thyroid secretion
43. The function of guard cells
44. Water and turgor pressure grid (for Investigation 18.1)
45. Diagrammatic summary of the reactions of photosynthesis
46. Light-dependent reactions of photosynthesis
47. A summary of the reactions in the Calvin cycle
48. The relationships between photosynthesis and cellular respiration
49. Paleontologic comparison grid (for Investigation 21.1)
50. Diagram of human evolution
51. Climatogram grids
52. The water cycle
53. The major ocean currents
54. The sulfur cycle
55. Map of areas sensitive to acid rain (for Investigation 23.4)
56. Map of the direction traveled by pollutants responsible for acid rain


mountain lions
third-level consumers
snakes
owls
foxes
second-level consumers
shrews
first-level consumers
birds
rabbits
mice
grasshoppers
spiders
producers
grass
raspberry bushes
decomposers

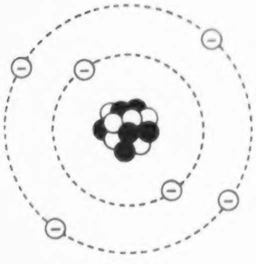
Location ____

	Height			
	0 cm	30 cm	90 cm	150 cm
Time				
Dry-bulb temperature				
Wet-bulb temperature				
Relative humidity				

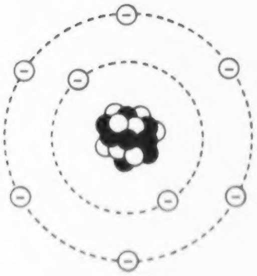

SPECIES
SPECIES
SPECIES



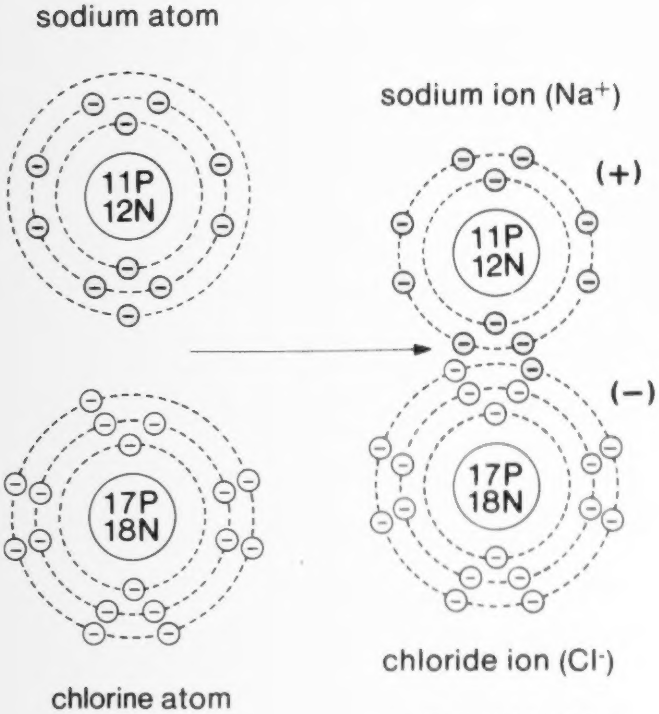
hydrogen



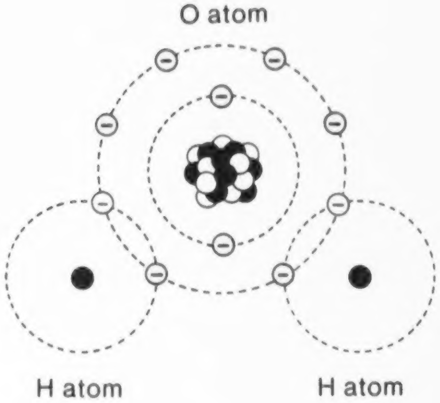
carbon



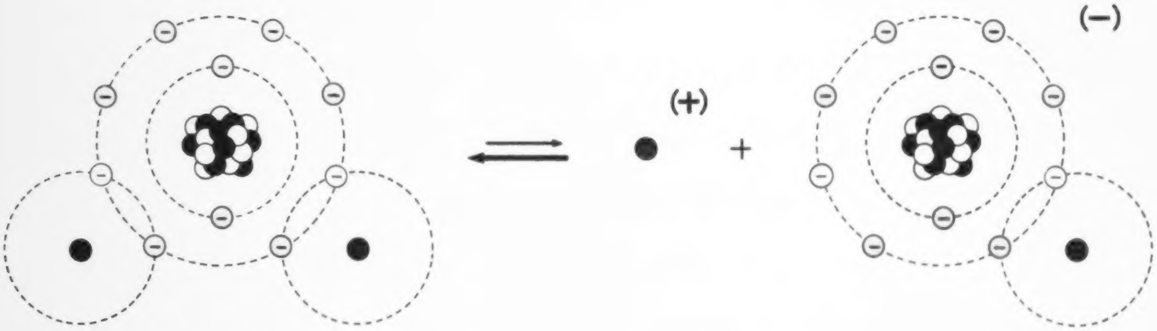
oxygen


sodium atom
11P
12N
sodium ion (Na+)
11P
12N
(+)
17P
18N
(−)
17P
18N
chloride ion (Cl-)
chlorine atom

sodium chloride


O atom
H atom
H atom

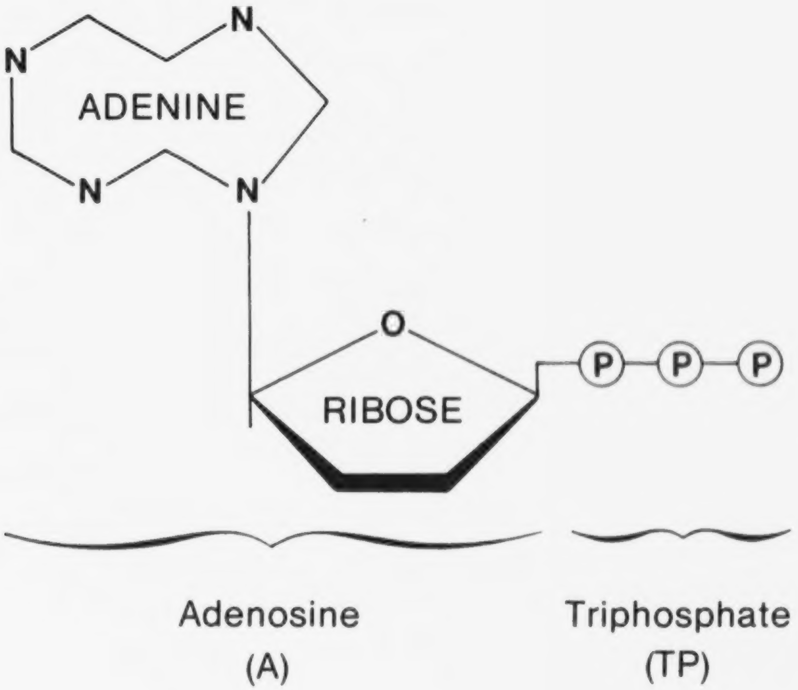
H_2O molecule

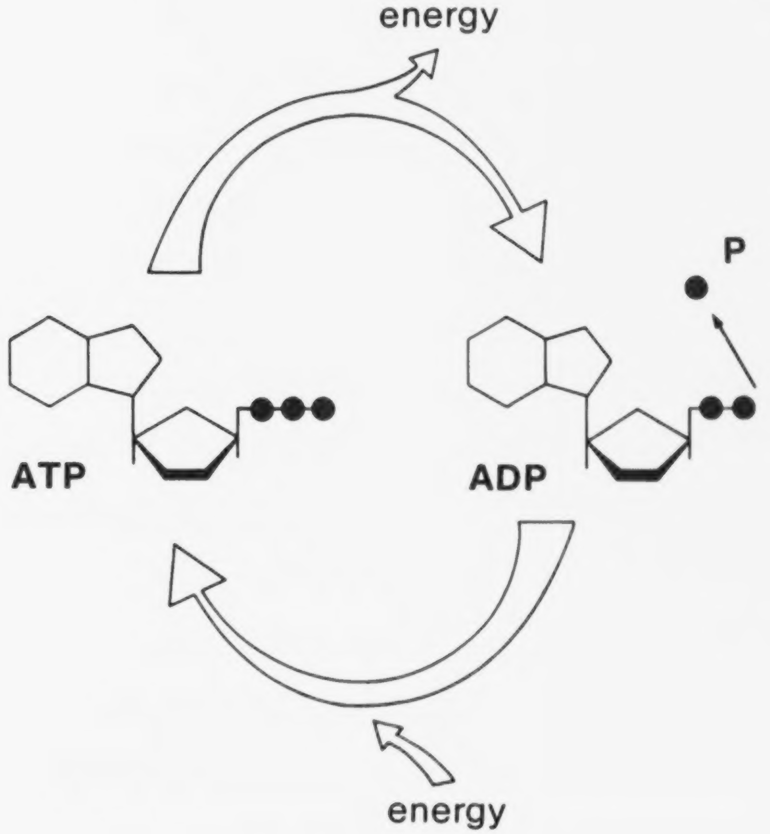


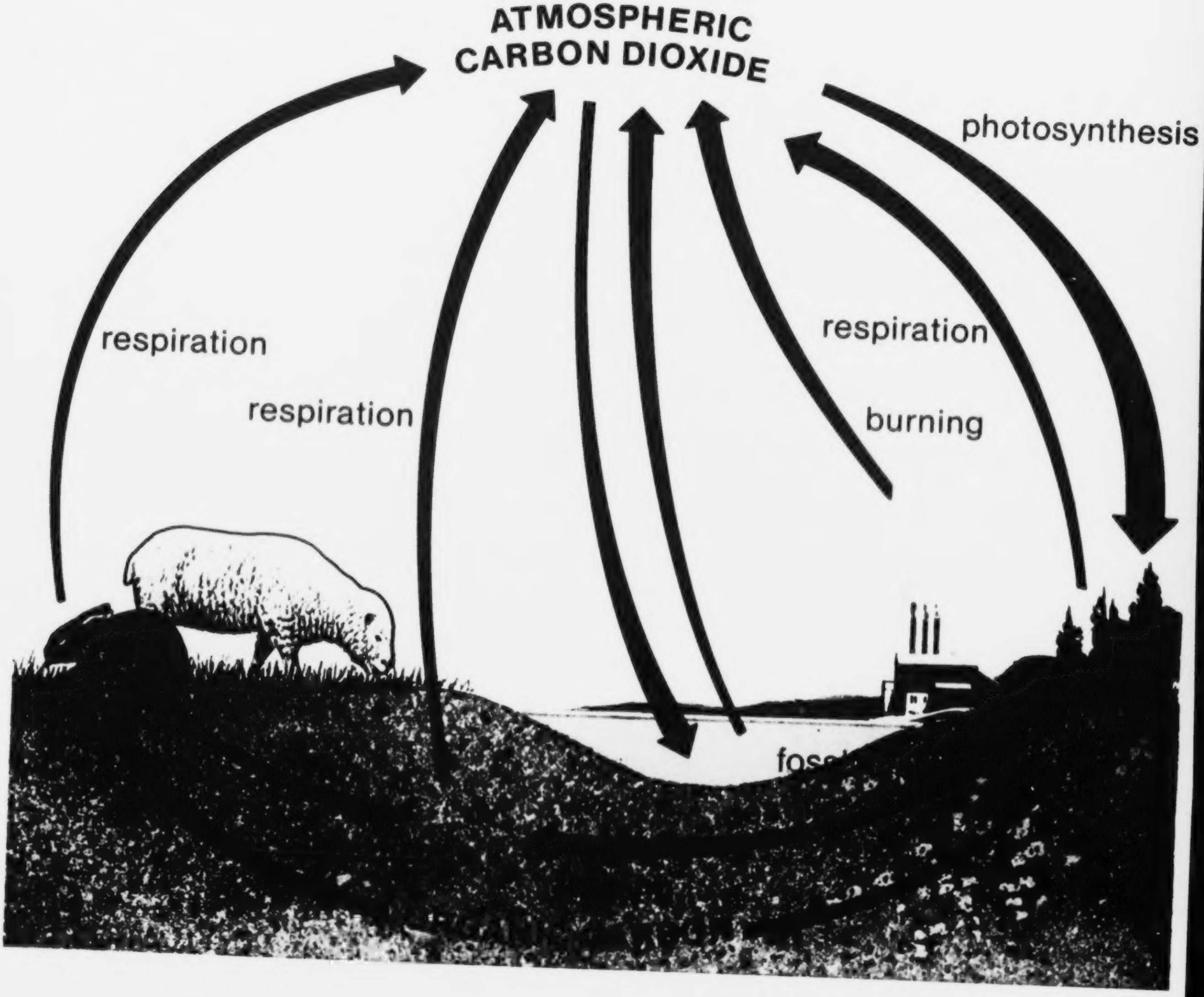
water molecule

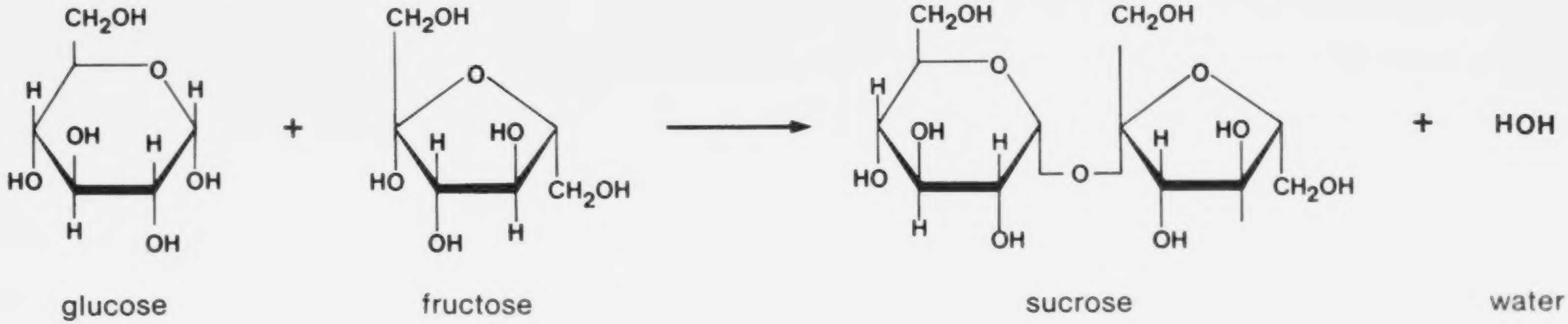
hydrogen ion (H^+)

hydroxide ion (OH^-)

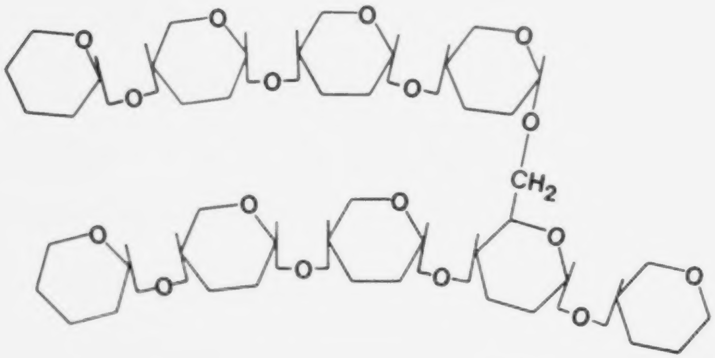

N
N
ADENINE
N
N
O
RIBOSE
P
P
P
Adenosine
(A)
Triphosphate
(TP)


energy
P
ATP
ADP
energy

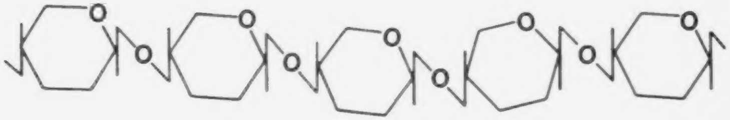

ATMOSPHERIC
CARBON DIOXIDE
photosynthesis
respiration
respiration
respiration
burning
fos


CH2OH
O
H
OH
HO
OH
OH
+
HOH
glucose
fructose
sucrose
water

a (monosaccharides) **b** (disaccharide)

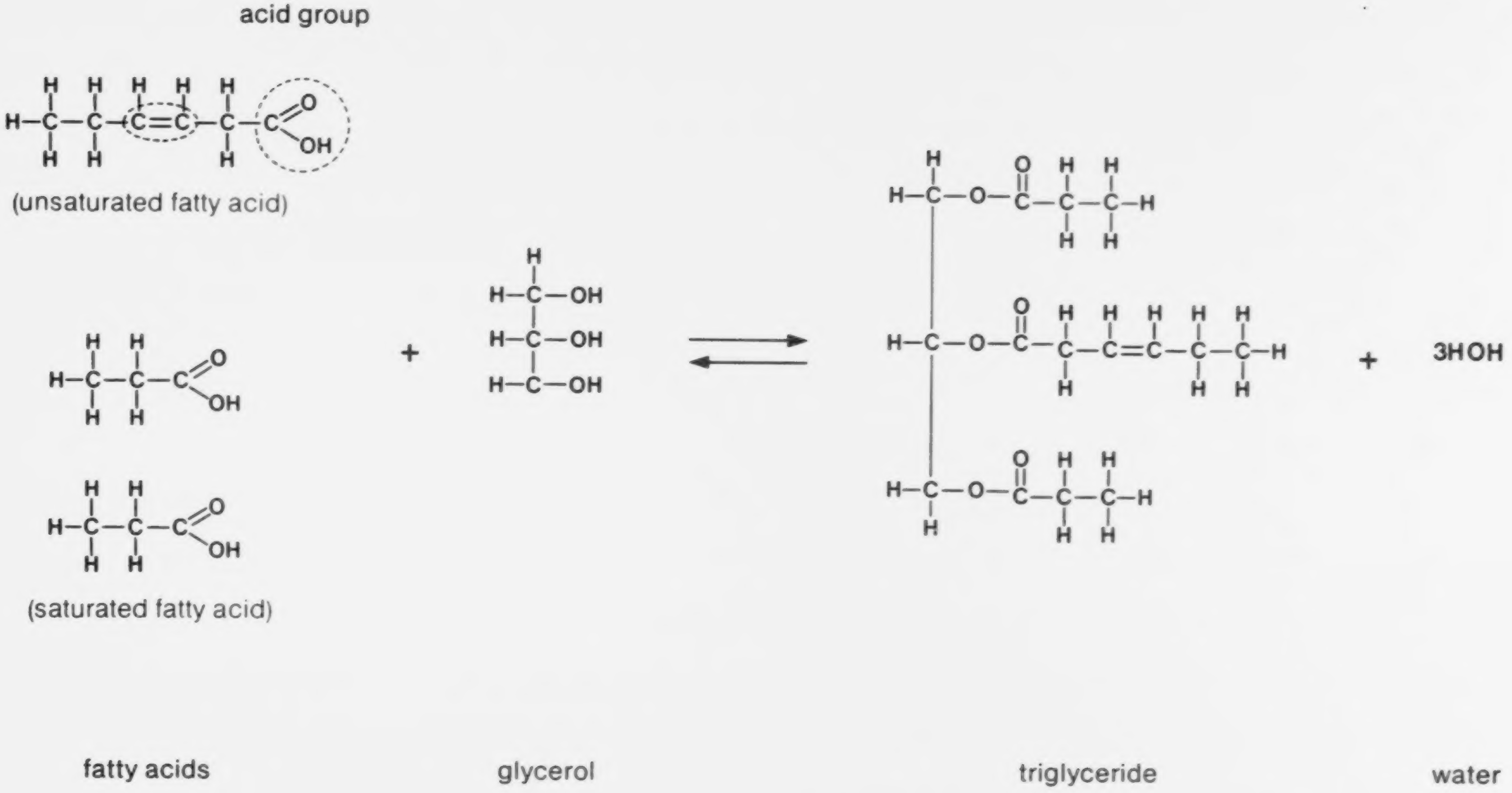


starch

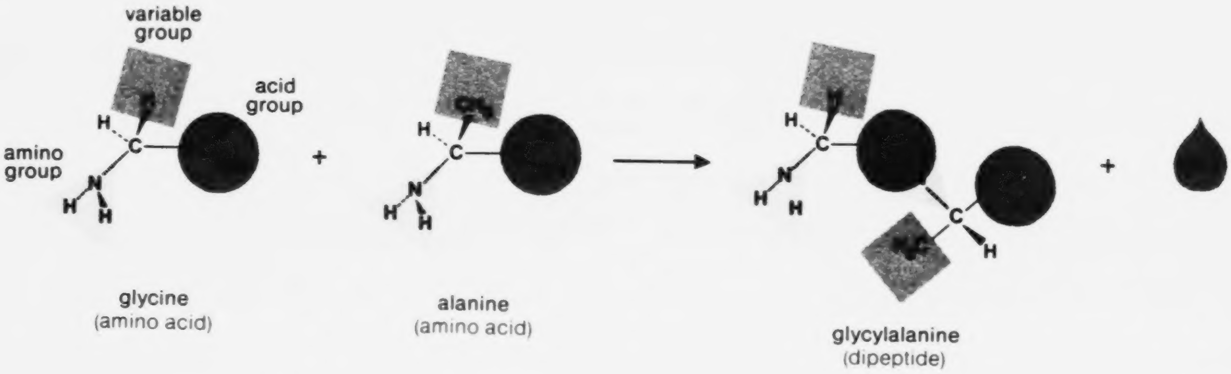


cellulose

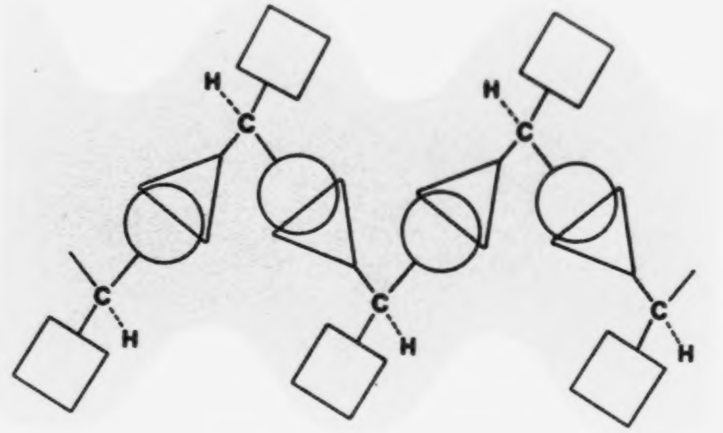
c (polysaccharides)


acid group
(unsaturated fatty acid)
(saturated fatty acid)
+
+
3HOH
fatty acids
glycerol
triglyceride
water

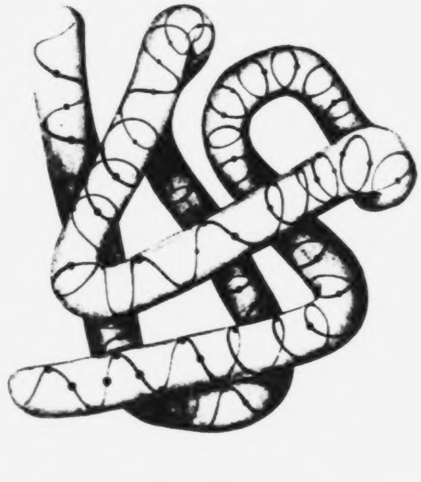
∞


variable group
acid group
amino group
H
C
N
H
H
+
CH_3
H_3C
+
glycine
(amino acid)
alanine
(amino acid)
glycylalanine
(dipeptide)

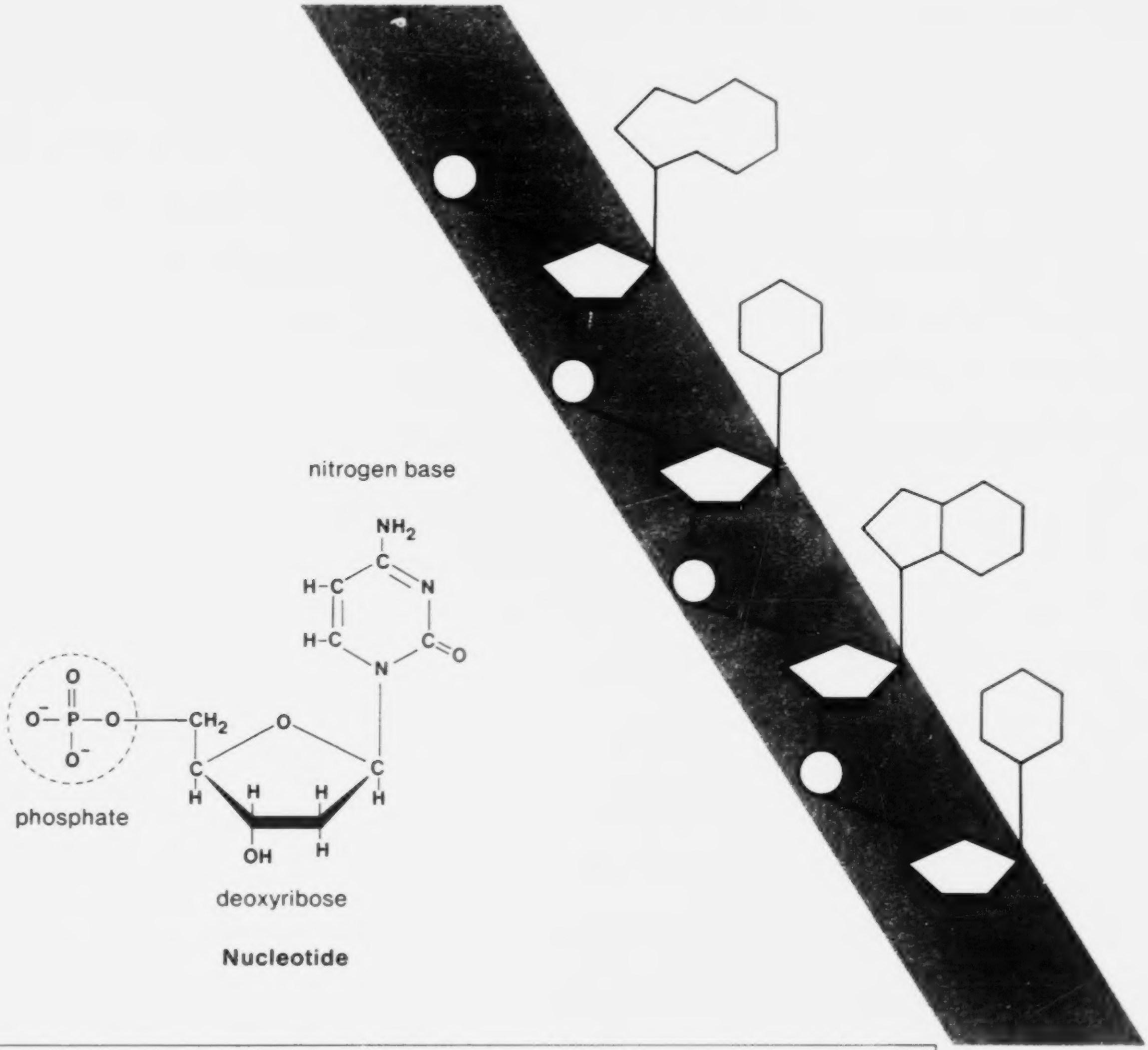
a.



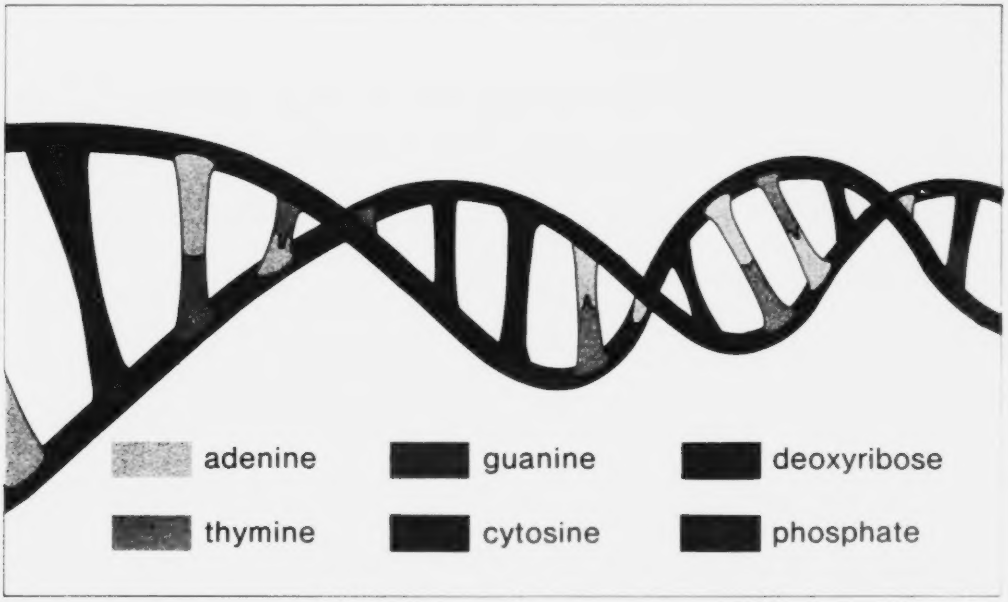
b. polypeptide chain

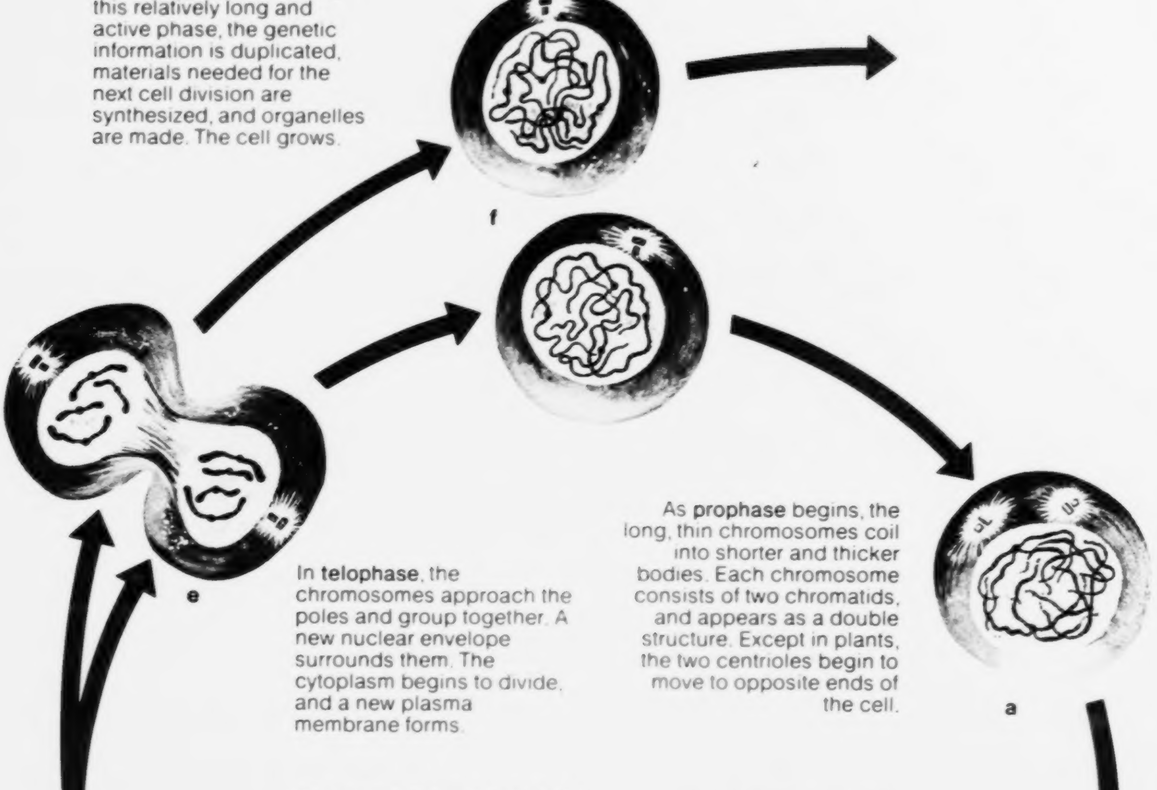


c. myoglobin


nitrogen base
NH_2
phosphate
deoxyribose

Nucleotide


adenine
guanine
deoxyribose
thymine
cytosine
phosphate



After cytokinesis is complete, new nuclear envelopes are completed. Each new cell enters **interphase.** During this relatively long and active phase, the genetic information is duplicated, materials needed for the next cell division are synthesized, and organelles are made. The cell grows.

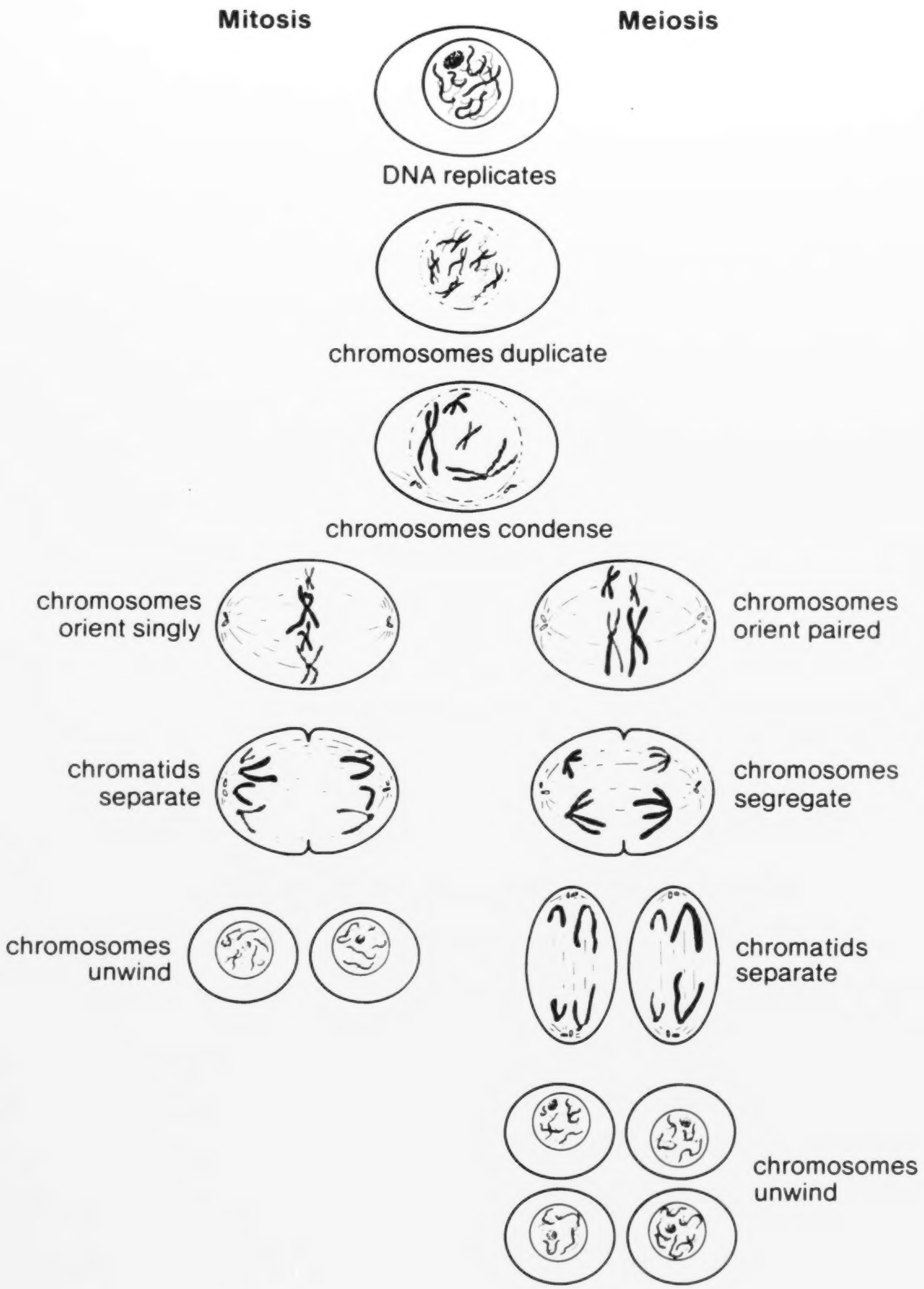
As **prophase** begins, the long, thin chromosomes coil into shorter and thicker bodies. Each chromosome consists of two chromatids, and appears as a double structure. Except in plants, the two centrioles begin to move to opposite ends of the cell.

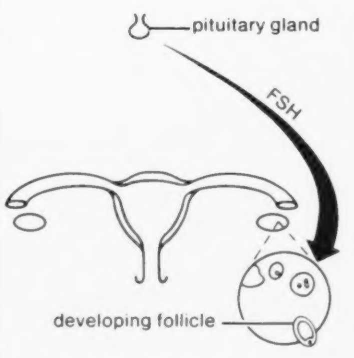
In **telophase**, the chromosomes approach the poles and group together. A new nuclear envelope surrounds them. The cytoplasm begins to divide, and a new plasma membrane forms.

Later in prophase, the nuclear envelope breaks down. The chromosomes contract to their shortest lengths. Spindle fibers stretch from pole to pole, and between each centromere and the nearest pole.

The centromeres divide and the two chromatids separate in **anaphase.** The new chromosomes are pushed and pulled to opposite ends of the cell by the spindle fibers.

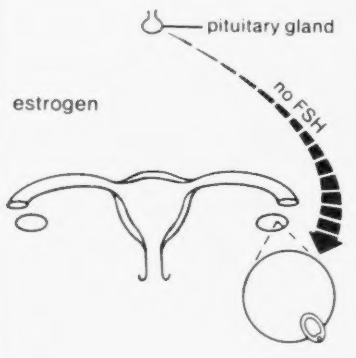
In **metaphase** each chromosome (two chromatids) aligns itself on the spindle midway between the poles. The chromosomes lie on an equatorial plane.


Mitosis
Meiosis
DNA replicates
chromosomes duplicate
chromosomes condense
chromosomes orient singly
chromosomes orient paired
chromatids separate
chromosomes segregate
chromosomes unwind
chromatids separate
chromosomes unwind


pituitary gland
FSH
developing follicle

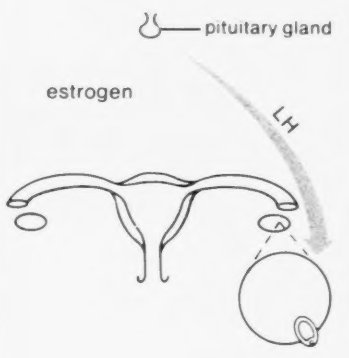
a

FSH stimulates developing follicle.


pituitary gland
estrogen
no FSH

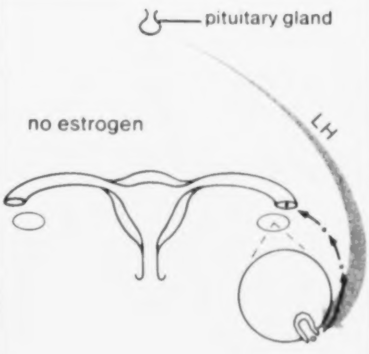
b.

Follicle produces estrogen; FSH production stops, uterine lining builds up.


pituitary gland
estrogen
LH

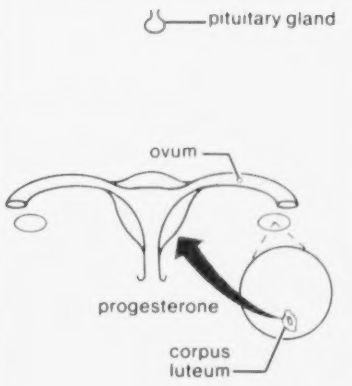
c

Estrogen stimulates pituitary's production of LH.


pituitary gland
no estrogen
LH

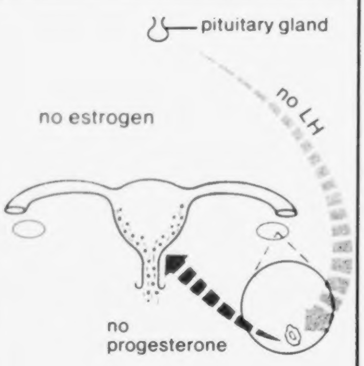
d

LH causes ovulation; ovum moves to fallopian tube. Estrogen production stops.


pituitary gland
ovum
progesterone
corpus luteum

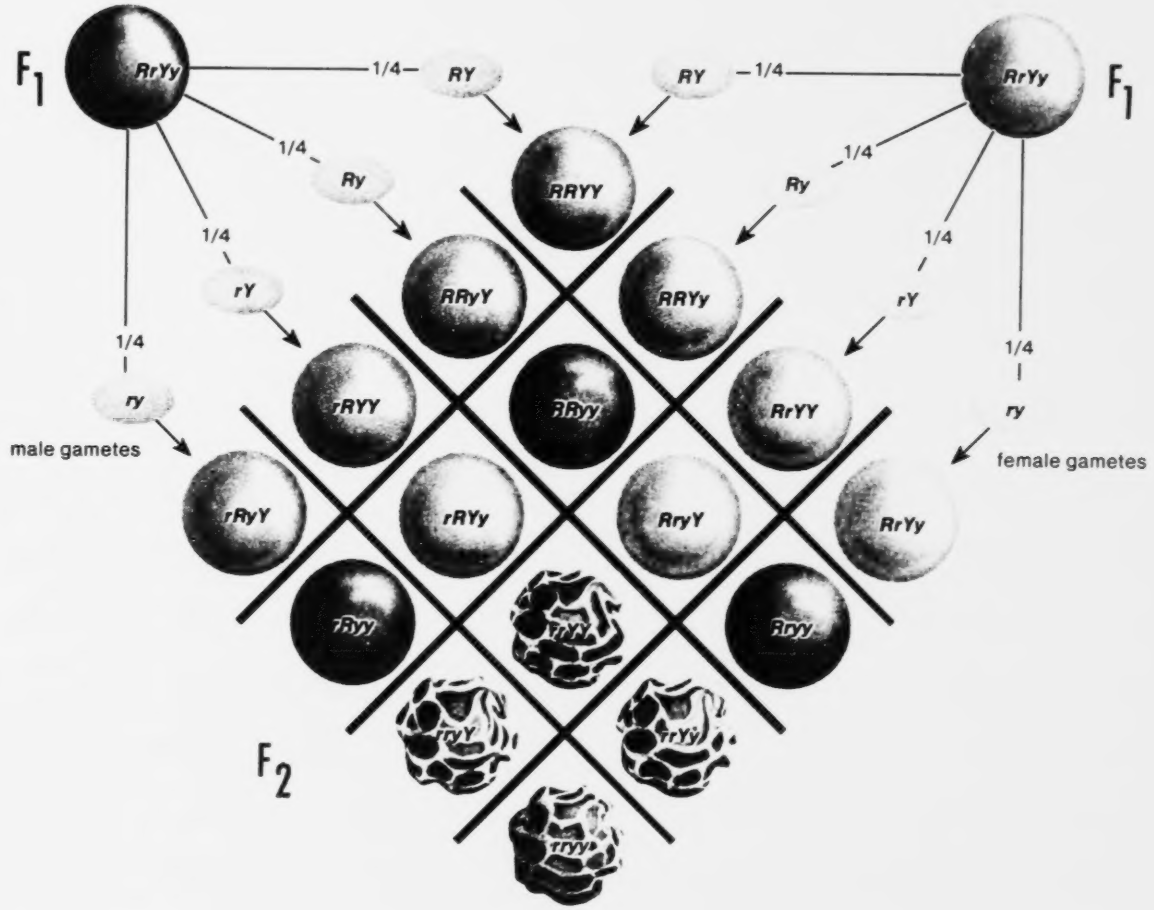
e

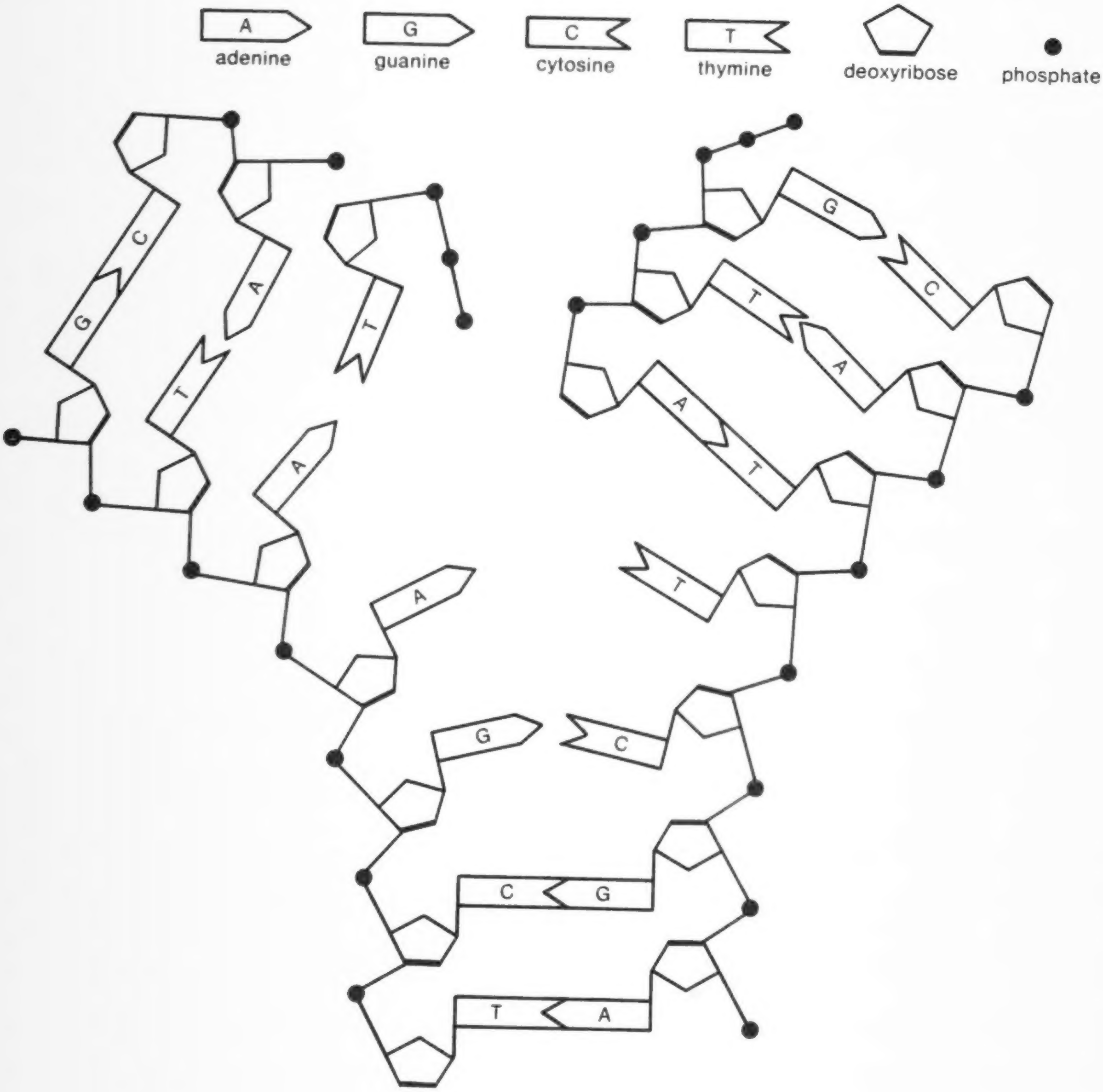
Follicle becomes corpus luteum. Progesterone from it maintains uterine lining.

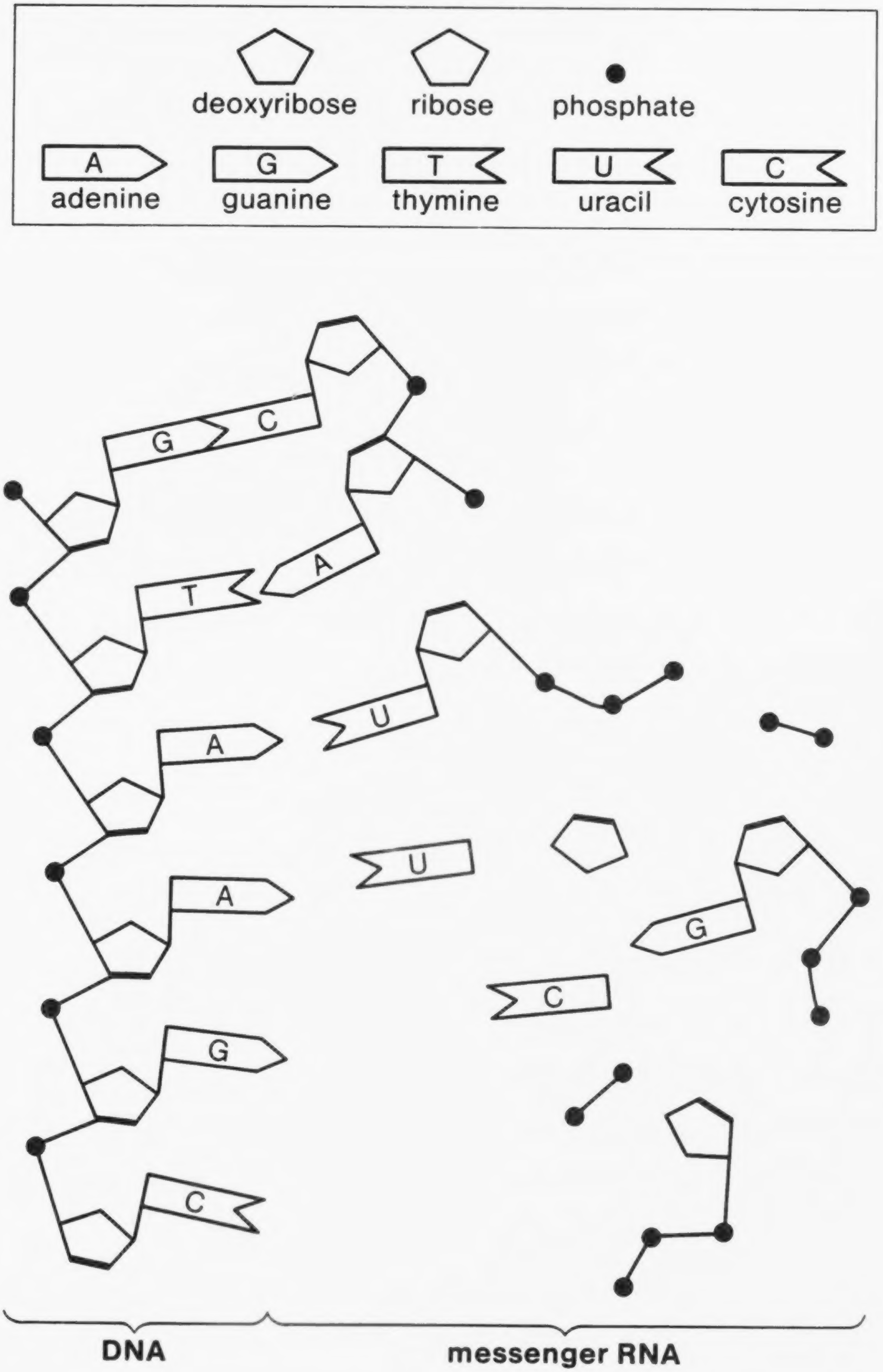

pituitary gland
no estrogen
no LH
no progesterone

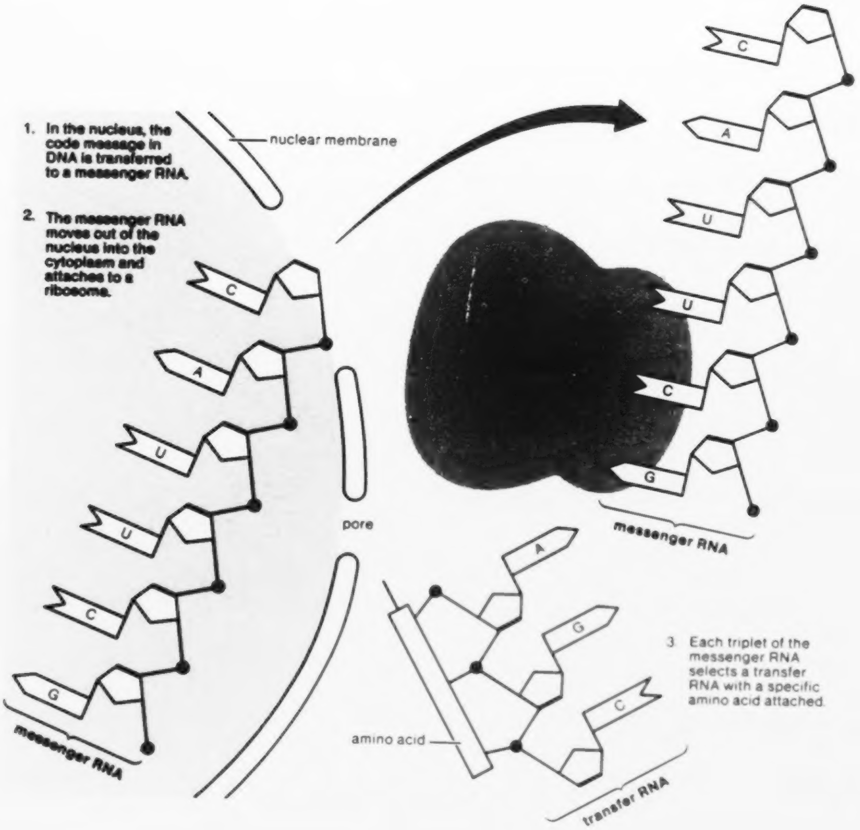
f

If ovum is not fertilized, then hormonal productions return to a low level. Uterine lining cannot be maintained and is sloughed off.


F1
RrYy
1/4
RY
1/4
Ry
1/4
rY
1/4
ry
male gametes
F1
RrYy
1/4
RY
1/4
Ry
1/4
rY
1/4
ry
female gametes
RRYY
RRyY
RRYy
rRYY
RRyy
RrYY
rRyY
rRYy
RryY
RrYy
rRyy
rrYY
Rryy
rryY
rrYy
rryy
F2


A
adenine
G
guanine
C
cytosine
T
thymine
deoxyribose
phosphate
G
C
A
T
T
A
A
G
C
T
A
A
T
C
A
T
G
C
C
G
T
A


deoxyribose
ribose
phosphate
A
adenine
G
guanine
T
thymine
U
uracil
C
cytosine
G
C
A
T
A
U
A
U
G
A
G
C
C
DNA
messenger RNA



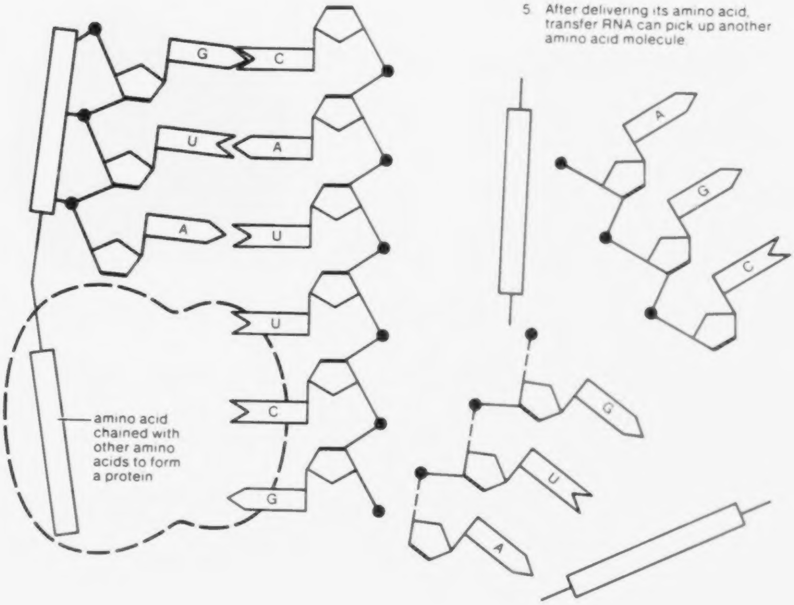
1. In the nucleus, the code message in DNA is transferred to a messenger RNA.

2. The messenger RNA moves out of the nucleus into the cytoplasm and attaches to a ribosome.

3. Each triplet of the messenger RNA selects a transfer RNA with a specific amino acid attached.

nuclear membrane
C
A
U
U
C
G
messenger RNA
pore
C
A
U
U
C
G
messenger RNA
A
G
C
amino acid
transfer RNA

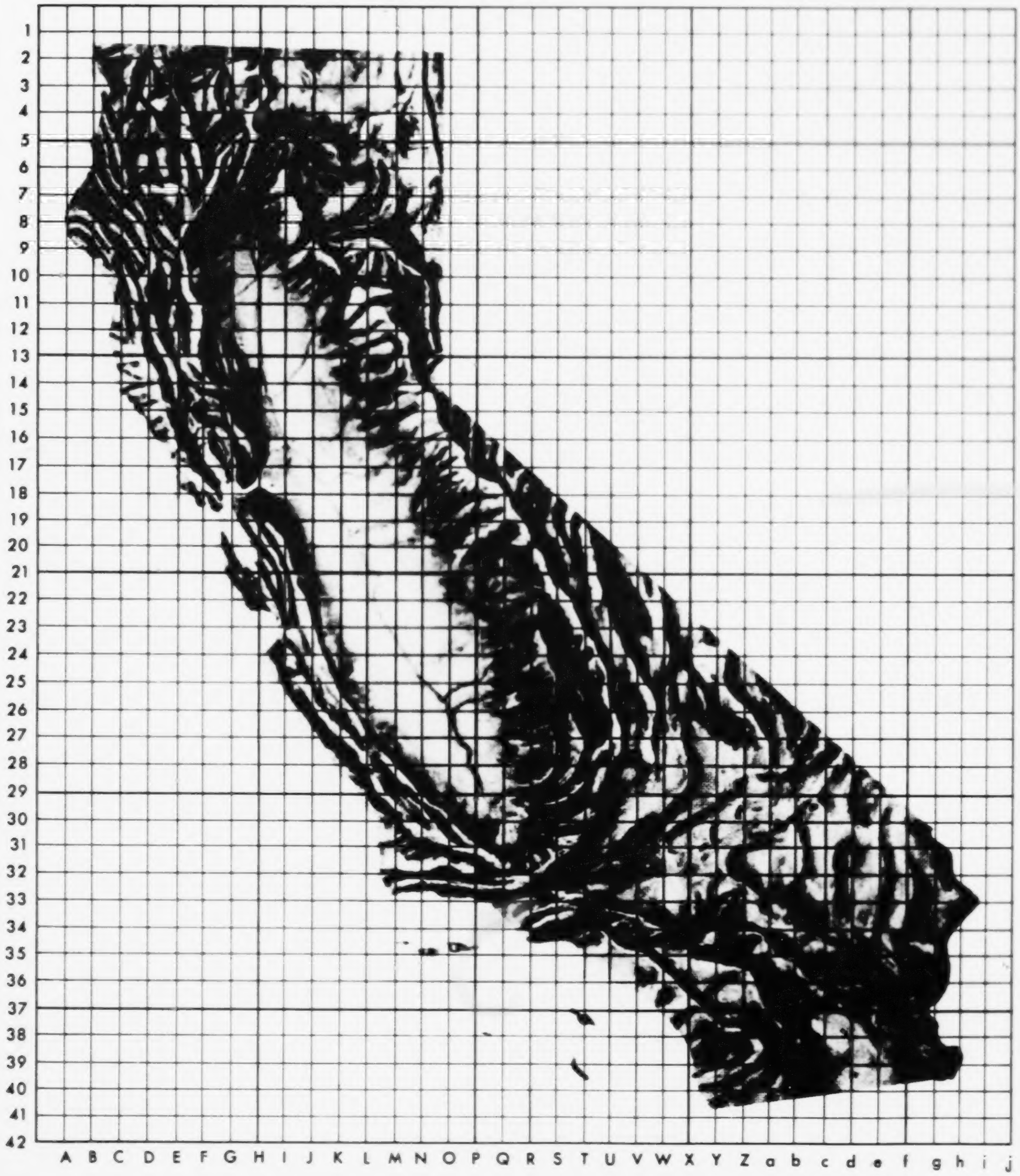
4. The ribosome moves along the messenger RNA as it "reads" the code. The amino acids are joined to each other in the order coded. A protein molecule isformed.



5. After delivering its amino acid, transfer RNA can pick up another amino acid molecule.

G
C
U
A
A
U
U
C
G
amino acid chained with other amino acids to form a protein
A
G
C
G
U
A

340


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
S
T
U
V
W
X
Y
Z
a
b
c
d
e
f
g
h
i
j

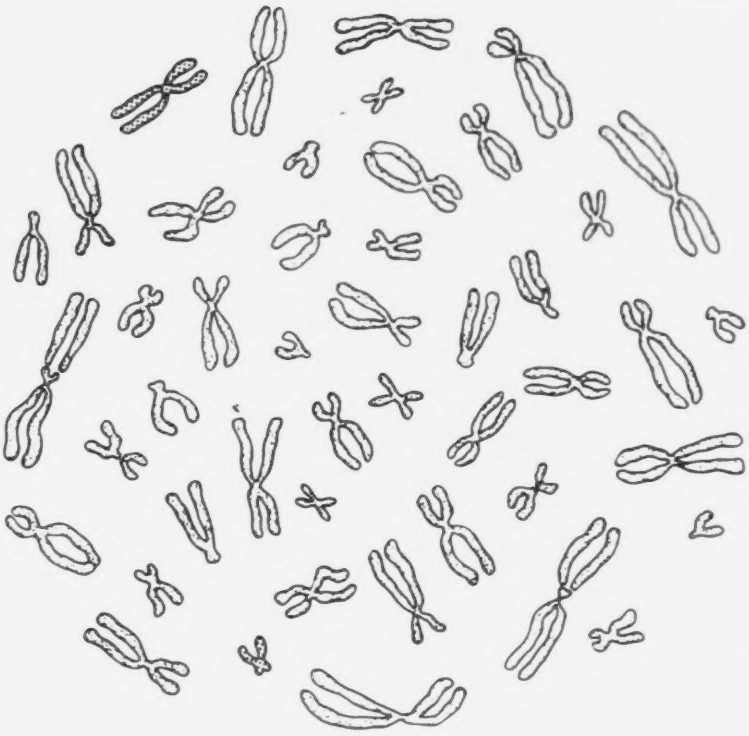


Figure A

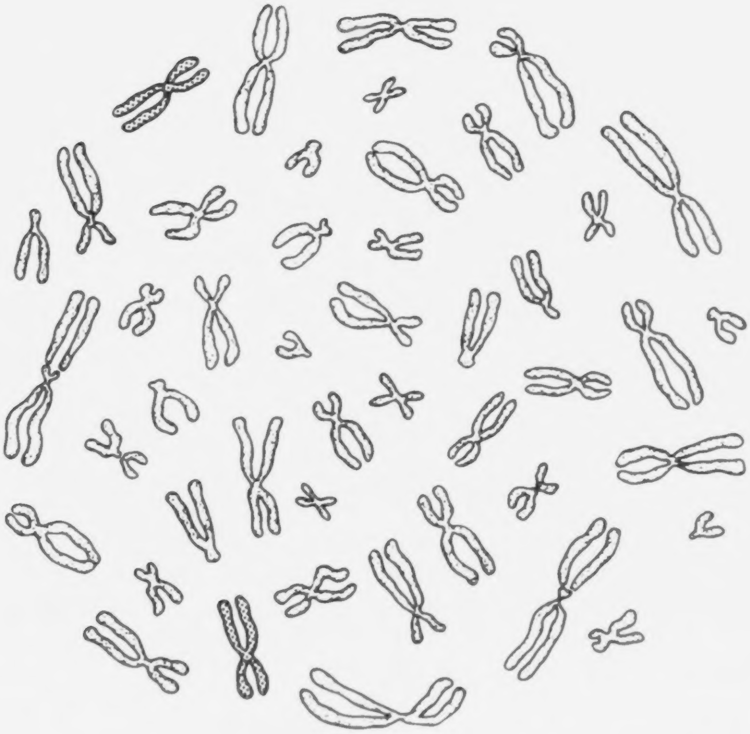


Figure B

A B

1 2 3 4 5

C

6 7 8 9 10 11 12

D E

13 14 15 16 17 18

F G

19 20 21 22 X X X Y

Karyotype A

A B

1 2 3 4 5

C

6 7 8 9 10 11 12

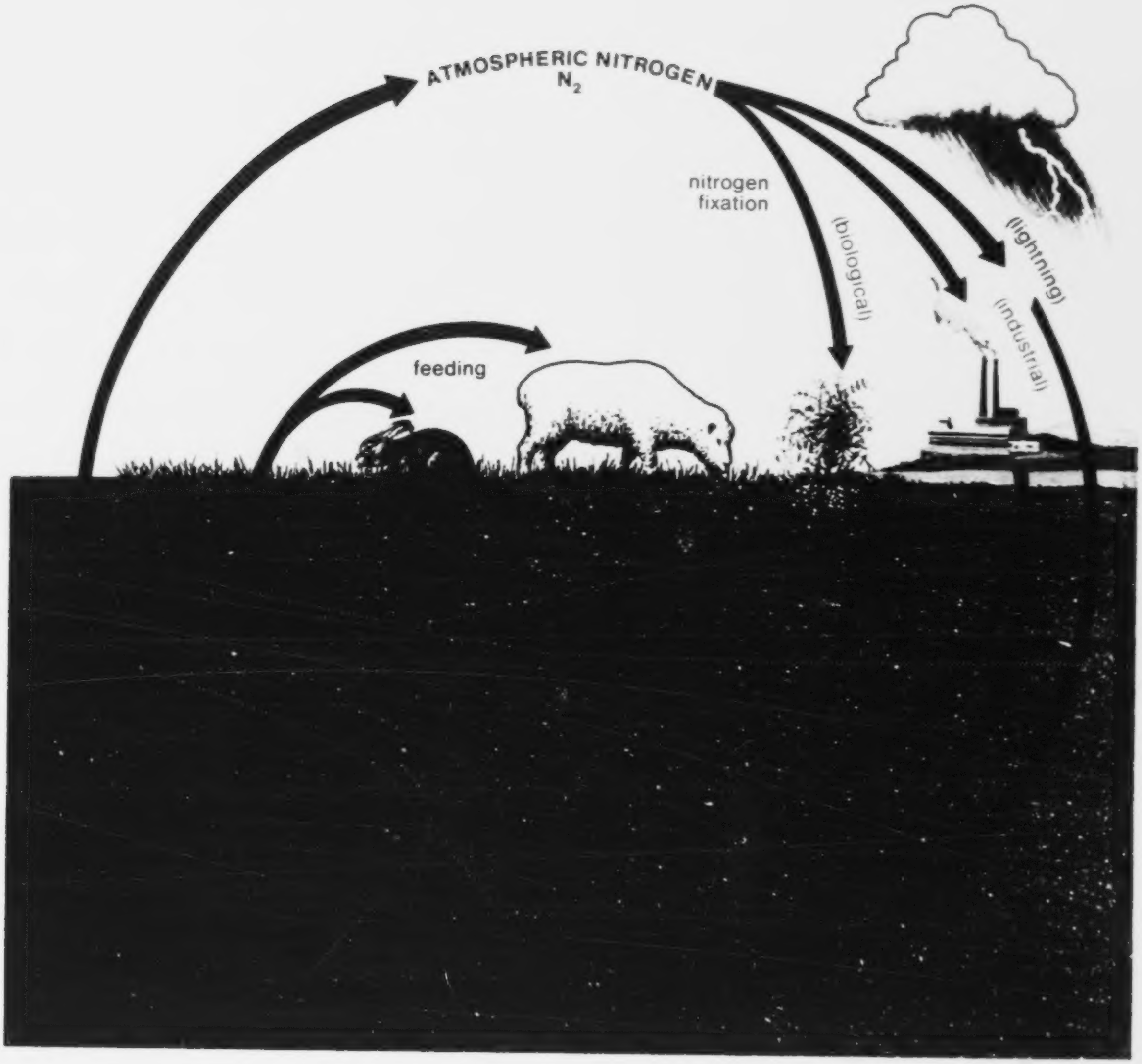
D E

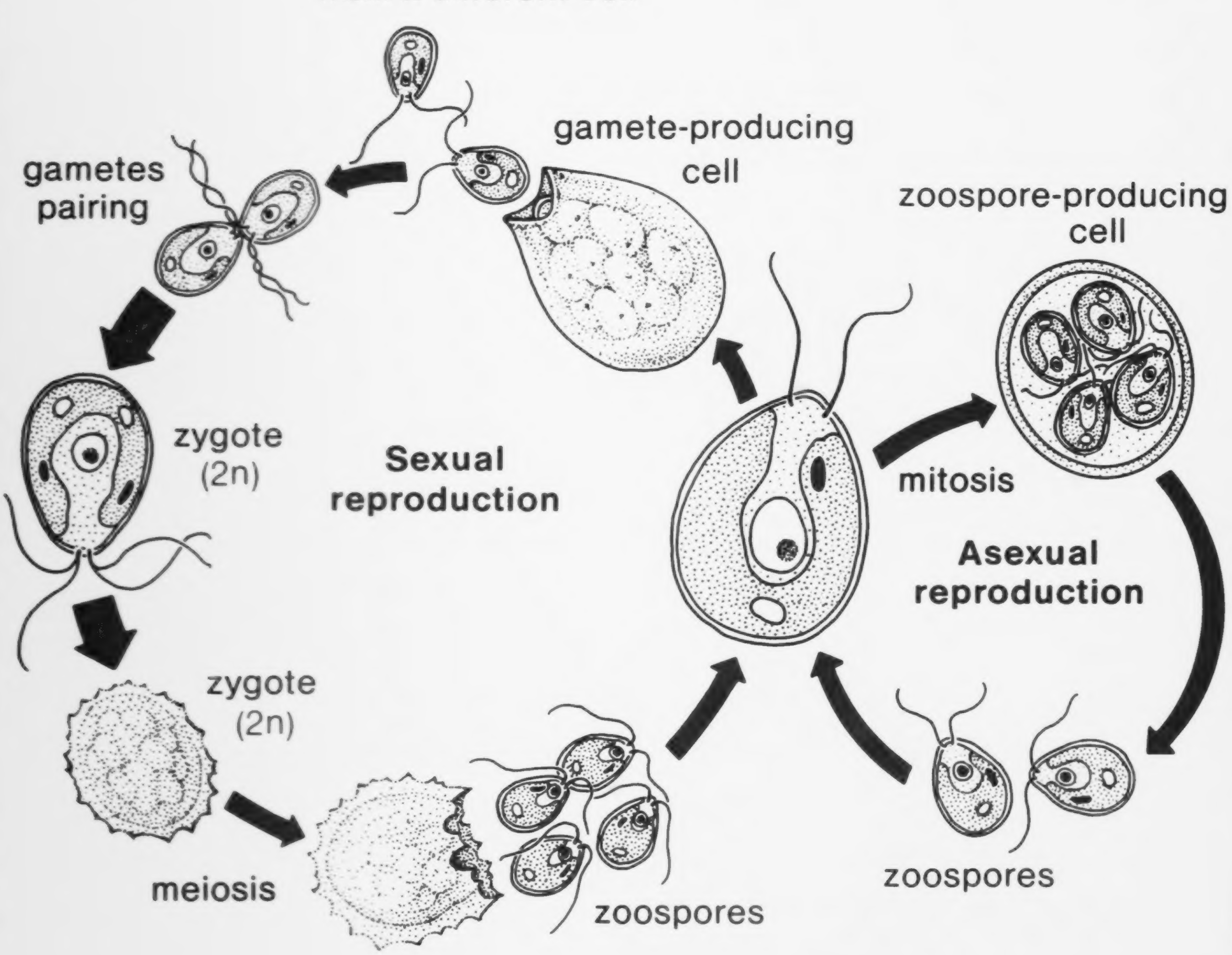
13 14 15 16 17 18

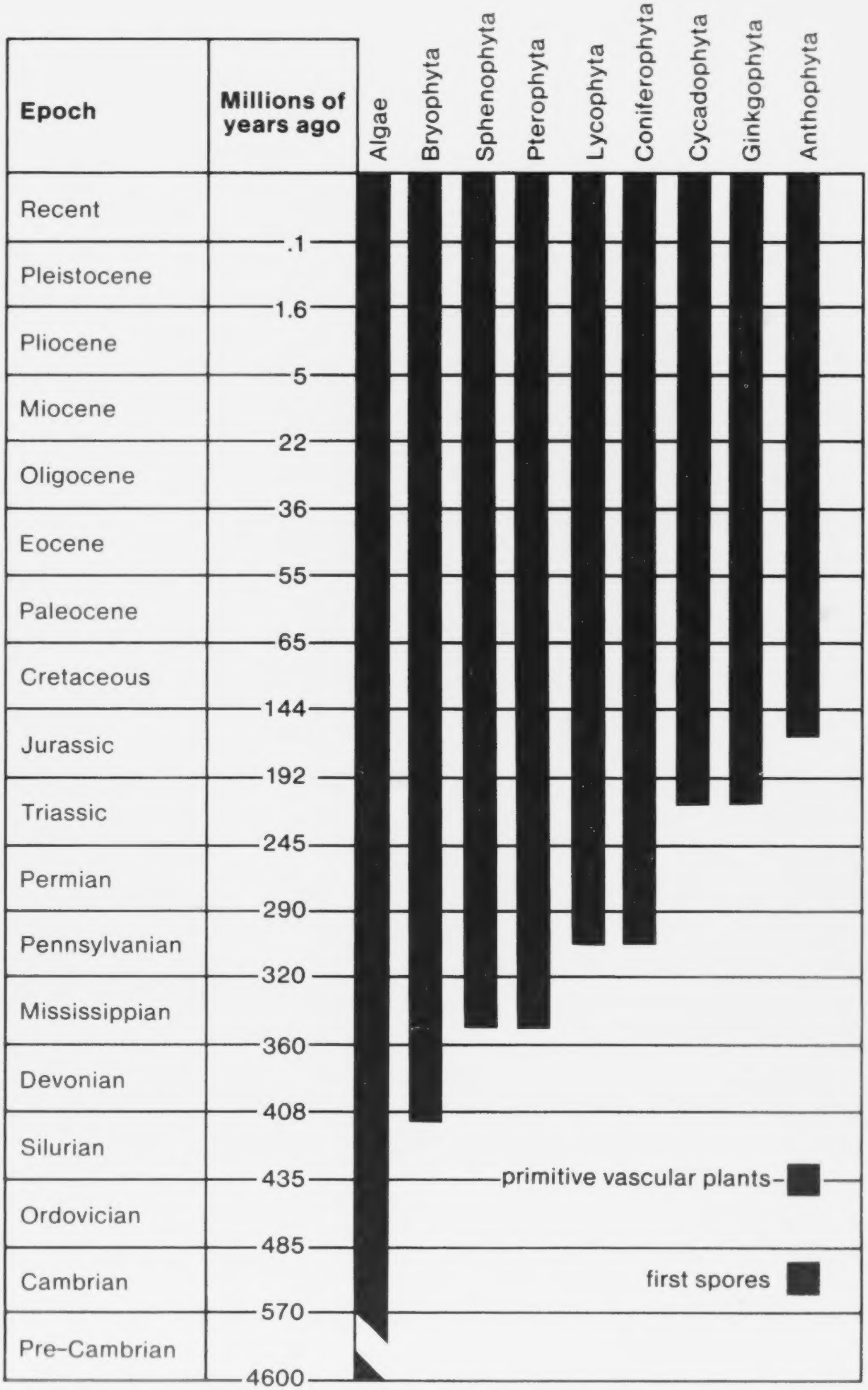
F G

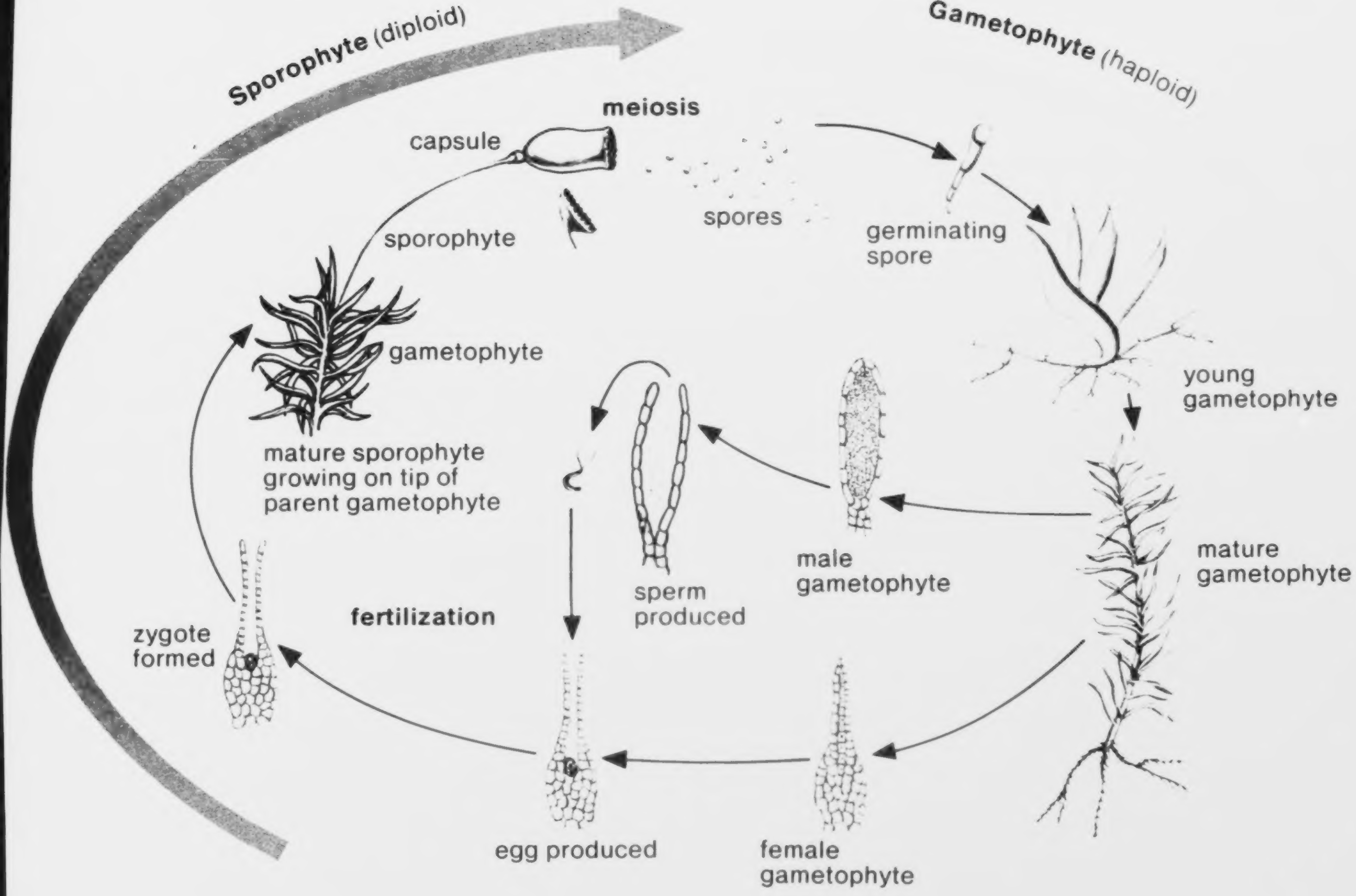
19 20 21 22 X X X Y

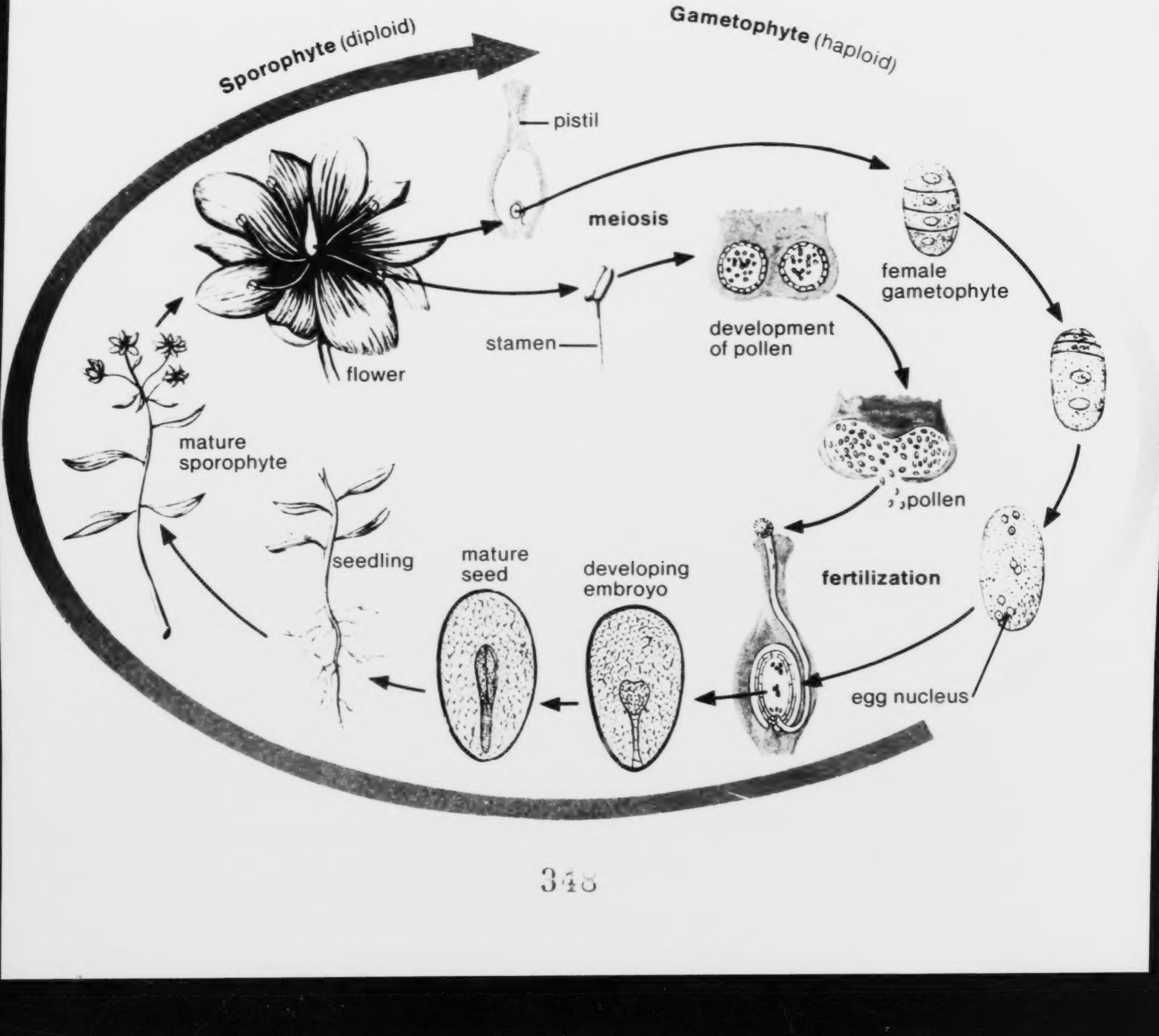
Karyotye B

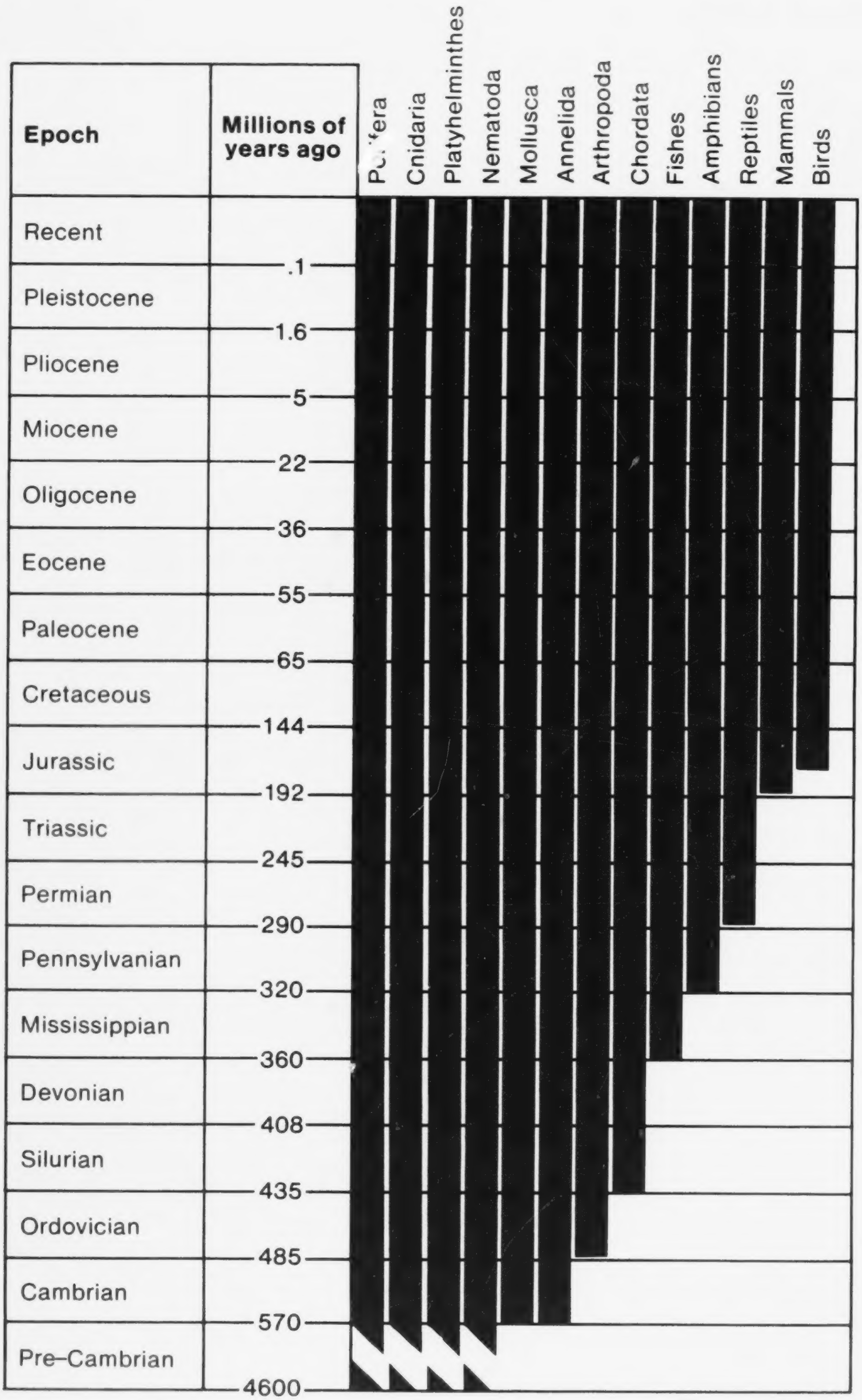

ATMOSPHERIC NITROGEN
N₂
nitrogen
fixation
(biological)
(industrial)
(lightning)
feeding

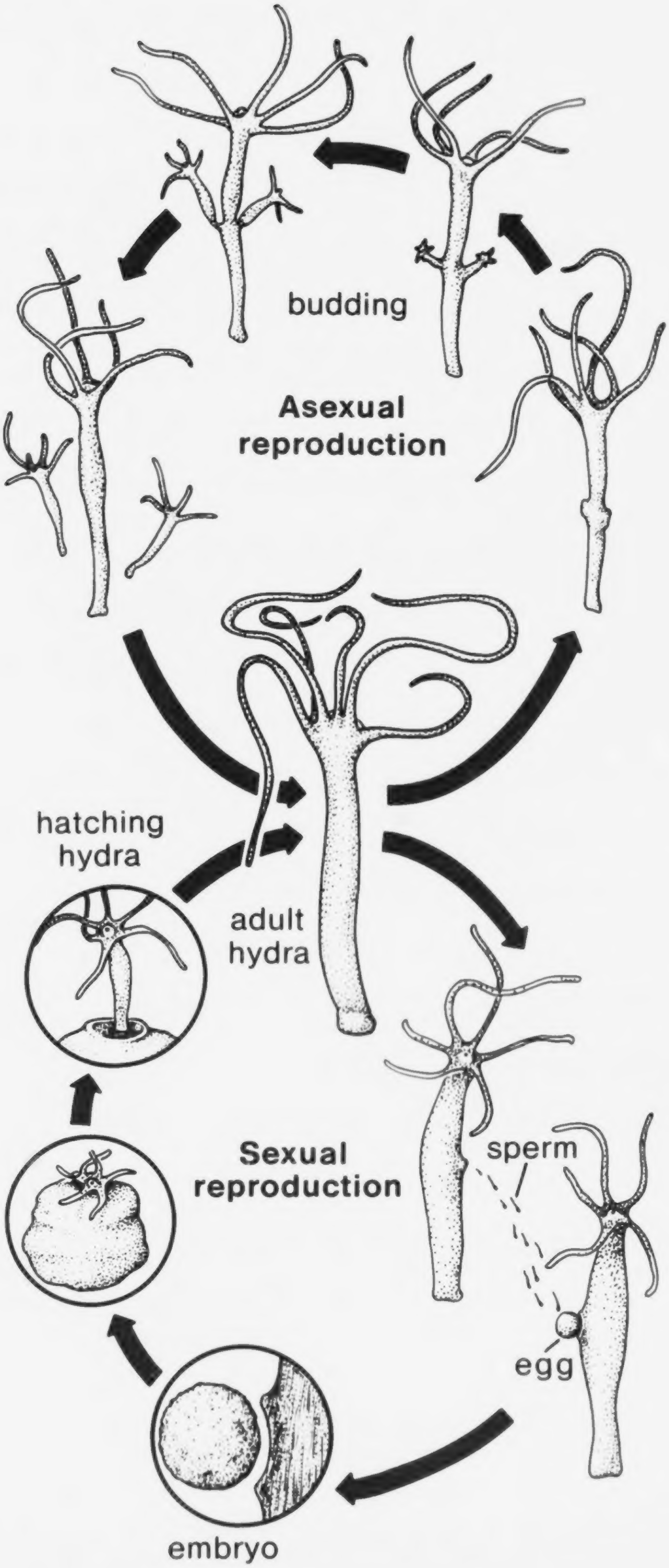

from a different cell
gamete-producing cell
gametes pairing
zoospore-producing cell
zygote (2n)
Sexual reproduction
mitosis
Asexual reproduction
zygote (2n)
meiosis
zoospores
zoospores

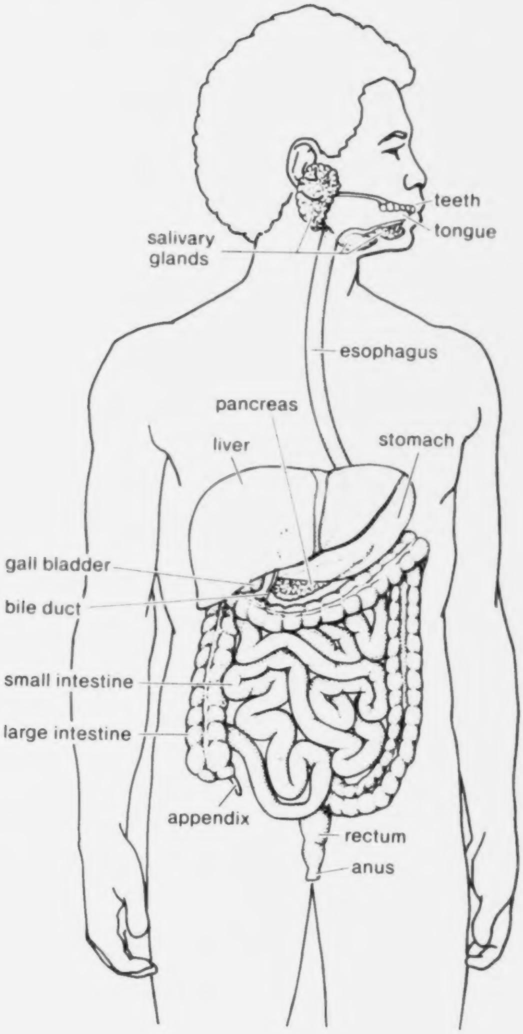

Epoch
Millions of years ago
Algae
Bryophyta
Sphenophyta
Pterophyta
Lycophyta
Coniferophyta
Cycadophyta
Ginkgophyta
Anthophyta
Recent
.1
Pleistocene
1.6
Pliocene
5
Miocene
22
Oligocene
36
Eocene
55
Paleocene
65
Cretaceous
144
Jurassic
192
Triassic
245
Permian
290
Pennsylvanian
320
Mississippian
360
Devonian
408
Silurian
435
Ordovician
485
Cambrian
570
Pre-Cambrian
4600
primitive vascular plants
first spores

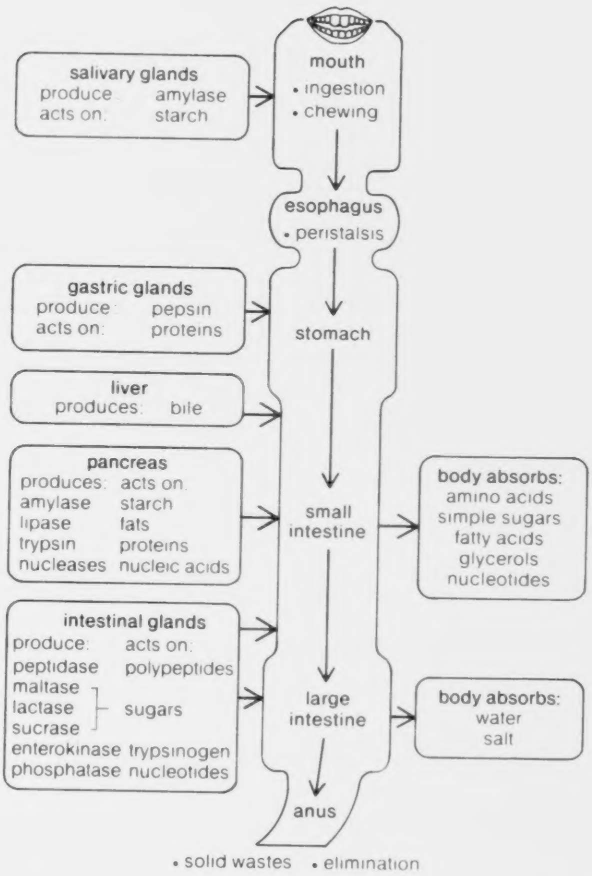

Sporophyte (diploid)
Gametophyte (*haploid*)
meiosis
capsule
spores
germinating spore
sporophyte
gametophyte
young gametophyte
mature sporophyte growing on tip of parent gametophyte
male gametophyte
sperm produced
mature gametophyte
fertilization
zygote formed
egg produced
female gametophyte

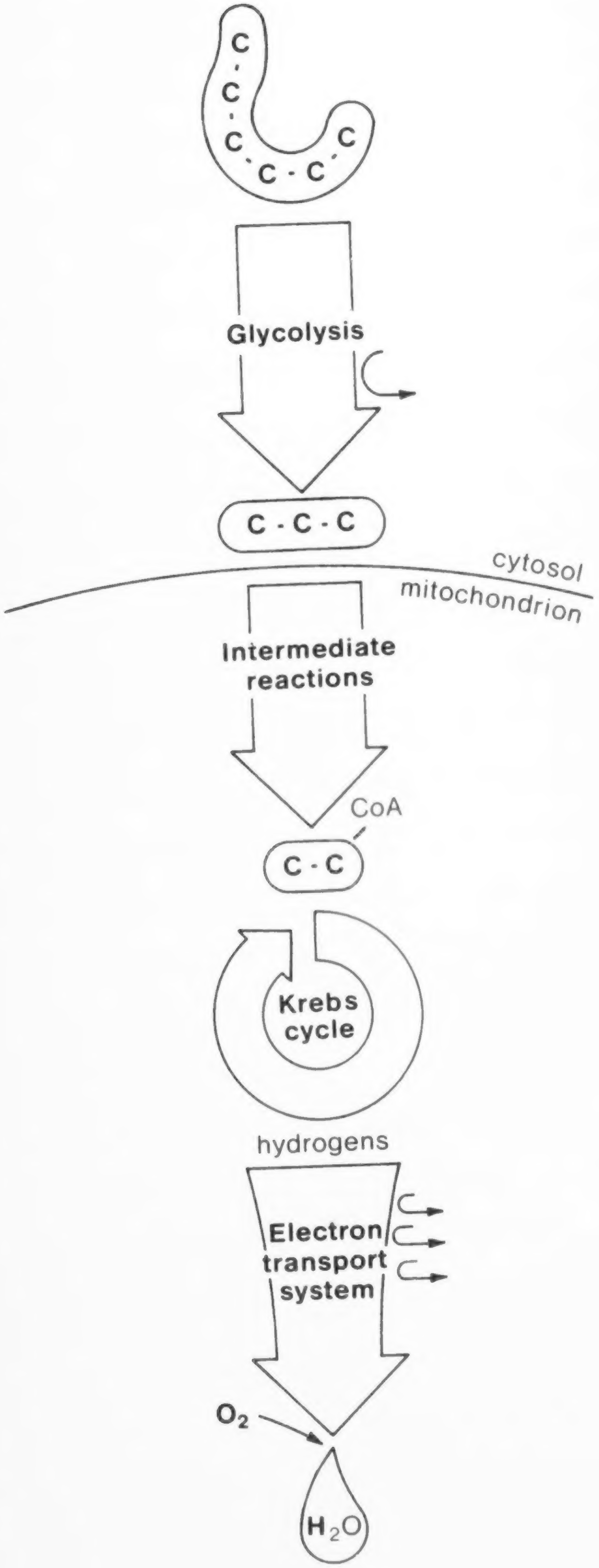

Sporophyte (diploid)
Gametophyte (haploid)
pistil
meiosis
female gametophyte
stamen
development of pollen
flower
mature sporophyte
pollen
fertilization
seedling
mature seed
developing embroyo
egg nucleus


Epoch
Millions of years ago
Porifera
Cnidaria
Platyhelminthes
Nematoda
Mollusca
Annelida
Arthropoda
Chordata
Fishes
Amphibians
Reptiles
Mammals
Birds
Recent
.1
Pleistocene
1.6
Pliocene
5
Miocene
22
Oligocene
36
Eocene
55
Paleocene
65
Cretaceous
144
Jurassic
192
Triassic
245
Permian
290
Pennsylvanian
320
Mississippian
360
Devonian
408
Silurian
435
Ordovician
485
Cambrian
570
Pre–Cambrian
4600

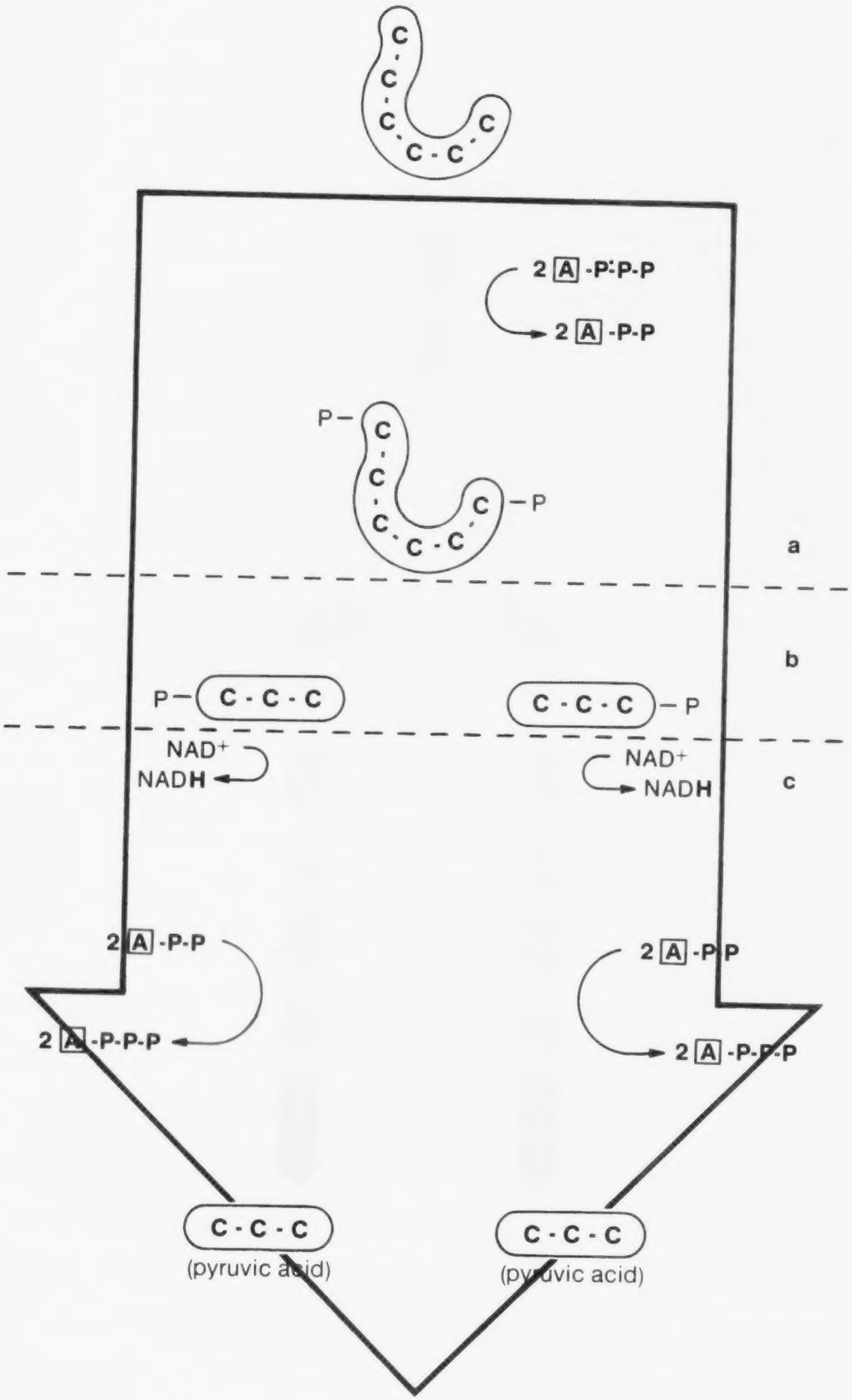

budding
Asexual reproduction
hatching hydra
adult hydra
Sexual reproduction
sperm
egg
embryo

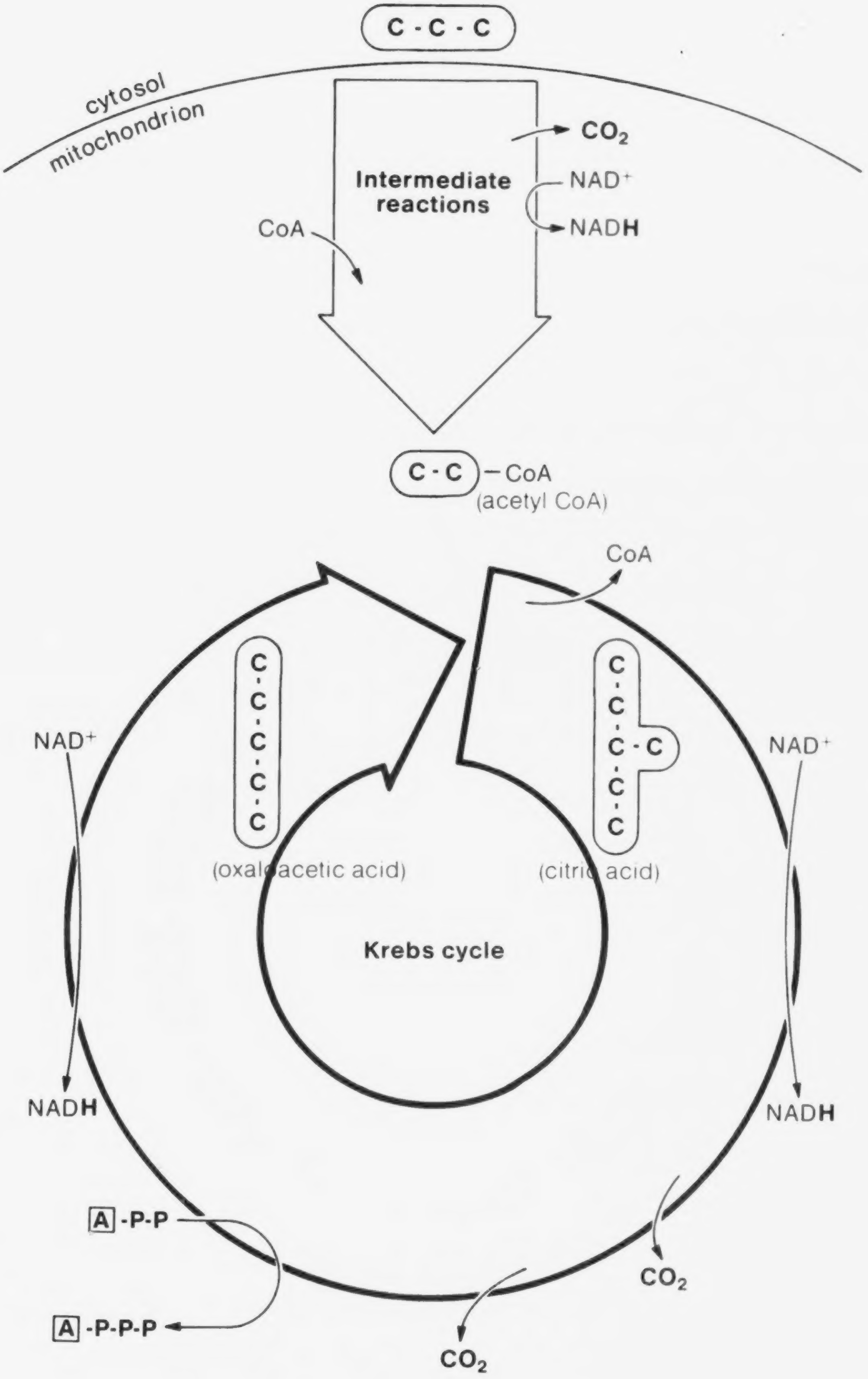

teeth
tongue
salivary glands
esophagus
pancreas
liver
stomach
gall bladder
bile duct
small intestine
large intestine
appendix
rectum
anus


salivary glands
produce: amylase
acts on: starch
mouth
• ingestion
• chewing
esophagus
• peristalsis
gastric glands
produce: pepsin
acts on: proteins
stomach
liver
produces: bile
pancreas
produces: acts on:
amylase starch
lipase fats
trypsin proteins
nucleases nucleic acids
small intestine
body absorbs:
amino acids
simple sugars
fatty acids
glycerols
nucleotides
intestinal glands
produce: acts on:
peptidase polypeptides
maltase
lactase
sucrase
sugars
enterokinase trypsinogen
phosphatase nucleotides
large intestine
body absorbs:
water
salt
anus
• solid wastes • elimination

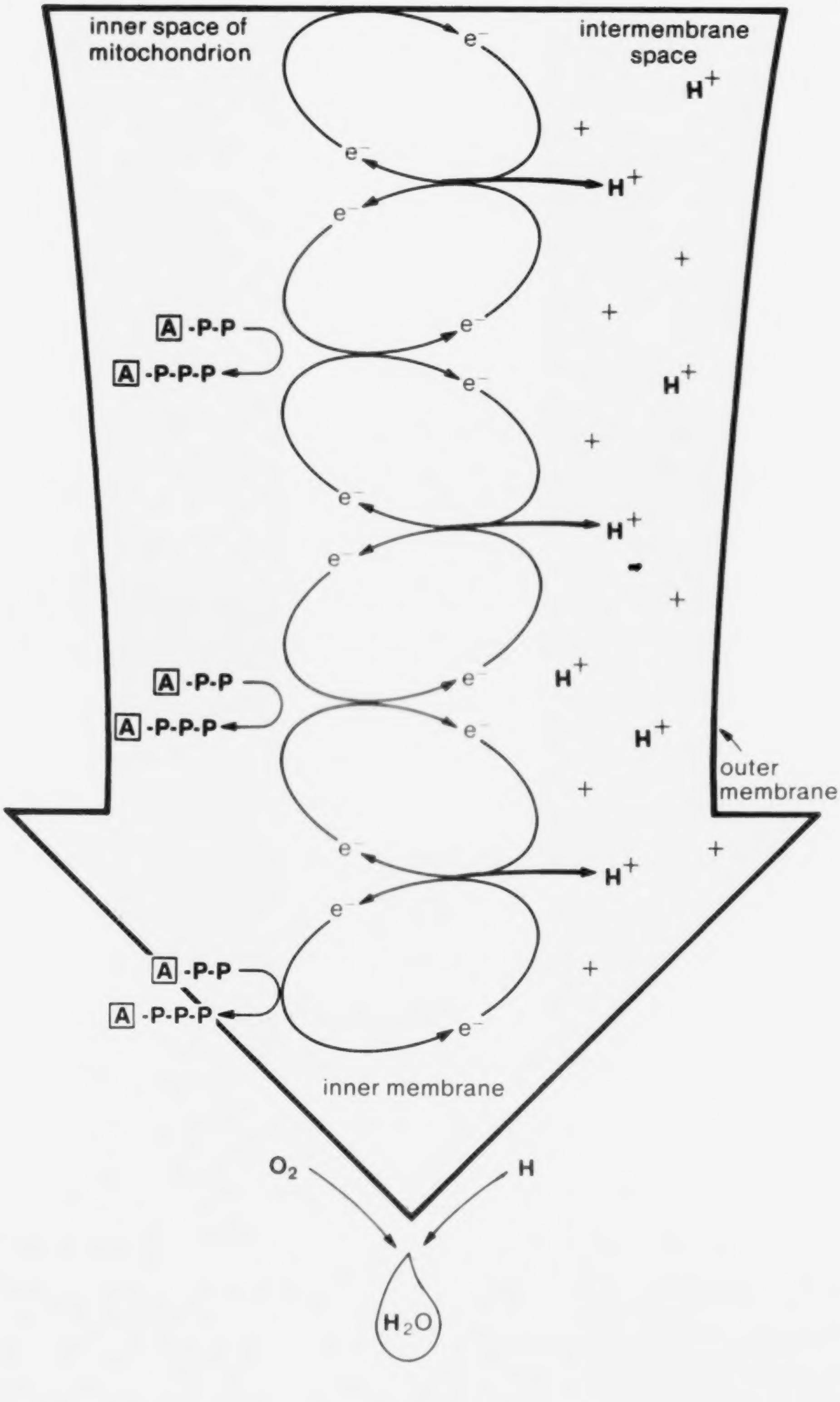

C
C
C
C
C
C
Glycolysis
C - C - C
cytosol
mitochondrion
Intermediate reactions
CoA
C - C
Krebs cycle
hydrogens
Electron transport system
O_2
H_2O

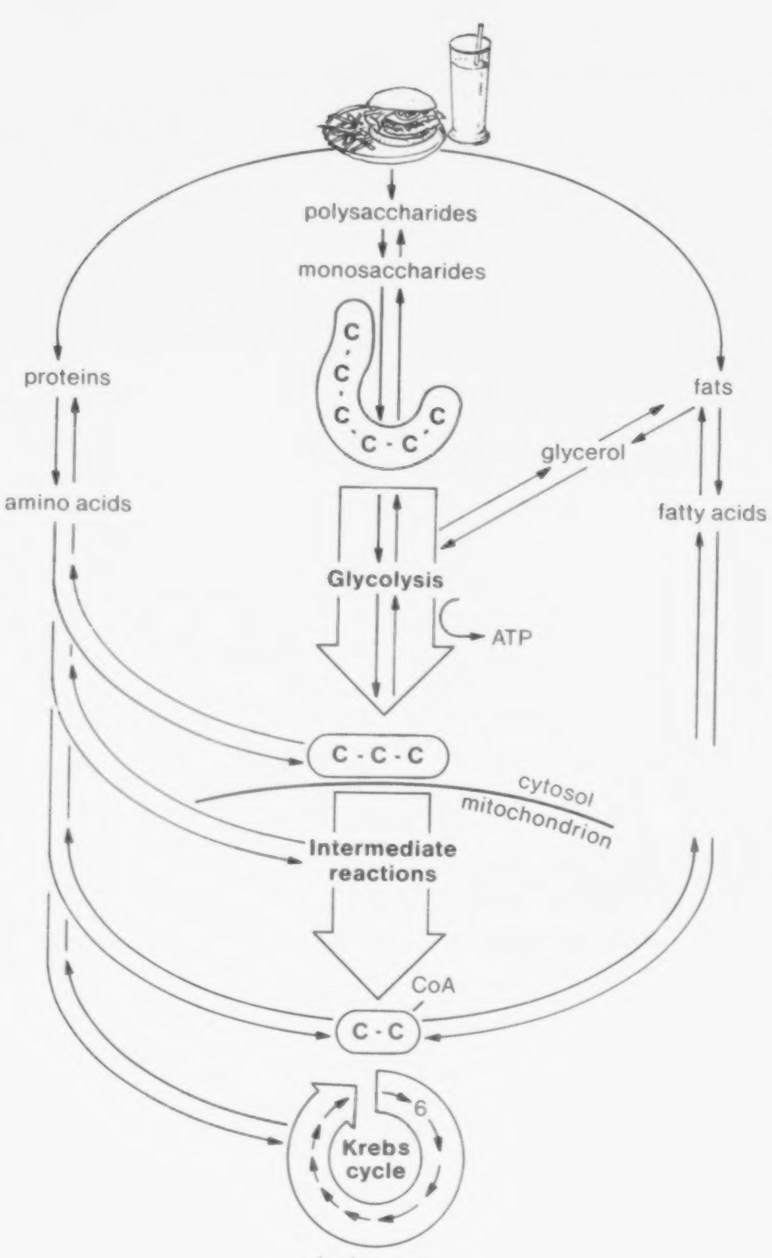
Glycolysis

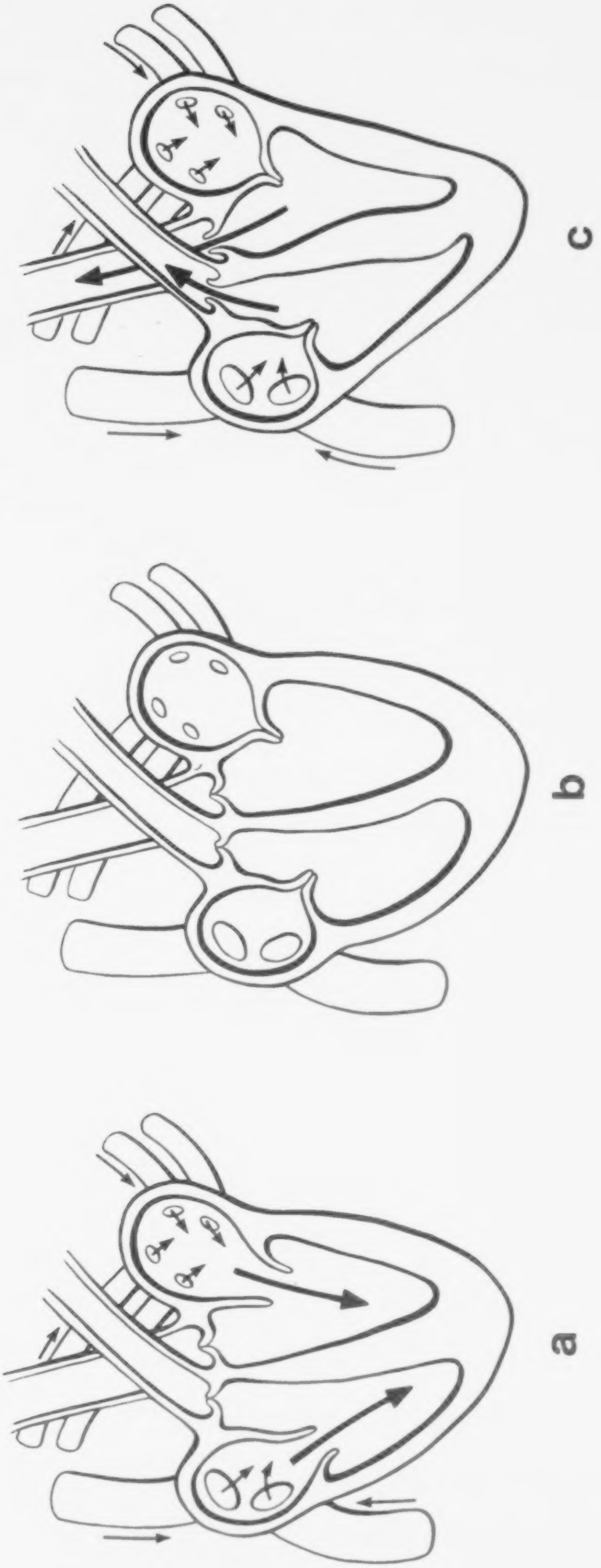

C · C · C · C · C · C
2 A -P-P-P
2 A -P-P
P — C · C · C · C · C · C — P
a
b
P — C · C · C
C · C · C — P
NAD+
NADH
NAD+
NADH
c
2 A -P-P
2 A -P-P-P
2 A -P-P
2 A -P-P-P
C · C · C
(pyruvic acid)
C · C · C
(pyruvic acid)

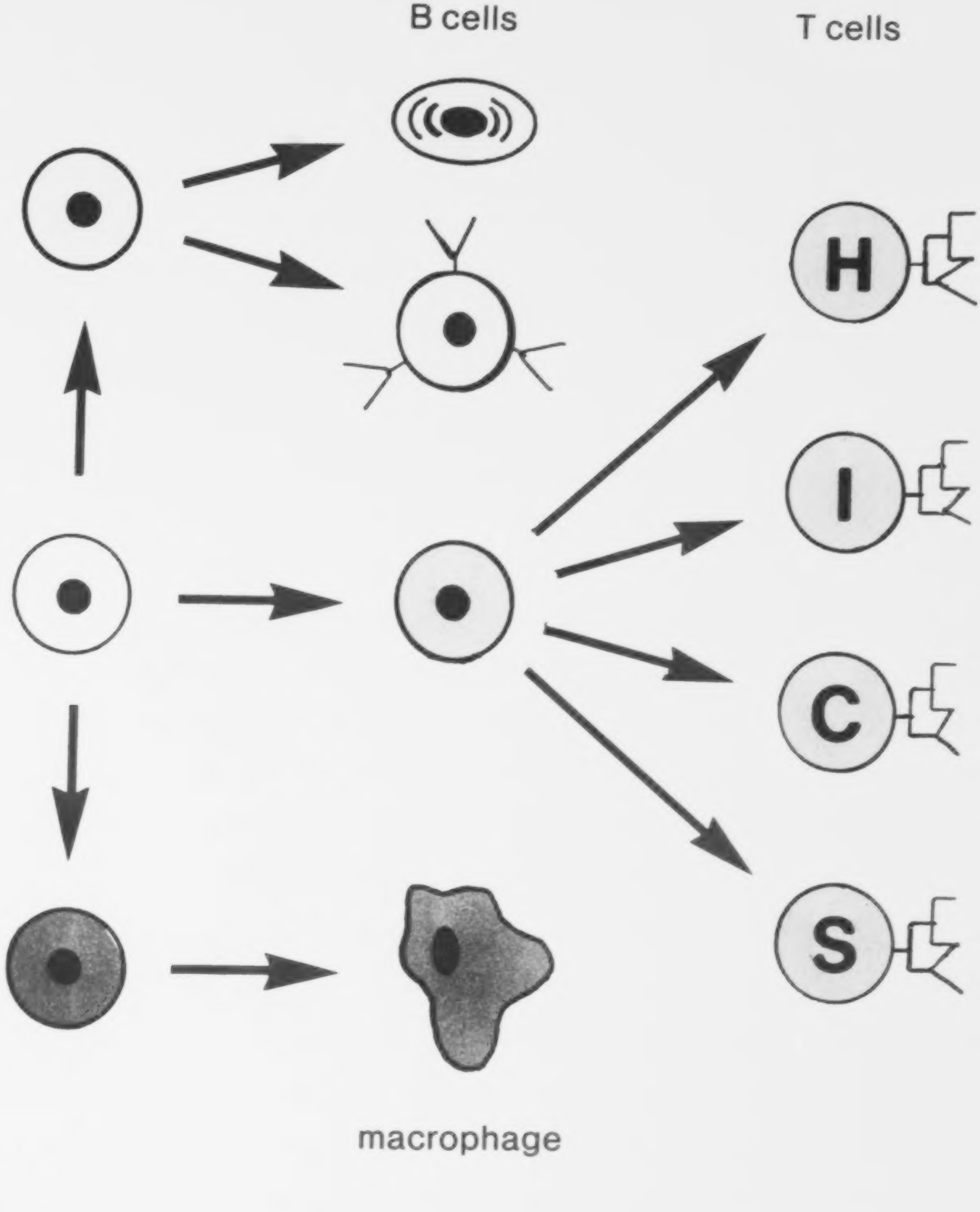

C · C · C
cytosol
mitochondrion
CO₂
Intermediate reactions
NAD⁺
NADH
CoA
C · C — CoA
(acetyl CoA)
CoA
C · C · C · C
(oxaloacetic acid)
C · C · C · C · C · C
(citric acid)
NAD⁺
NAD⁺
Krebs cycle
NADH
NADH
A -P-P
A -P-P-P
CO₂
CO₂

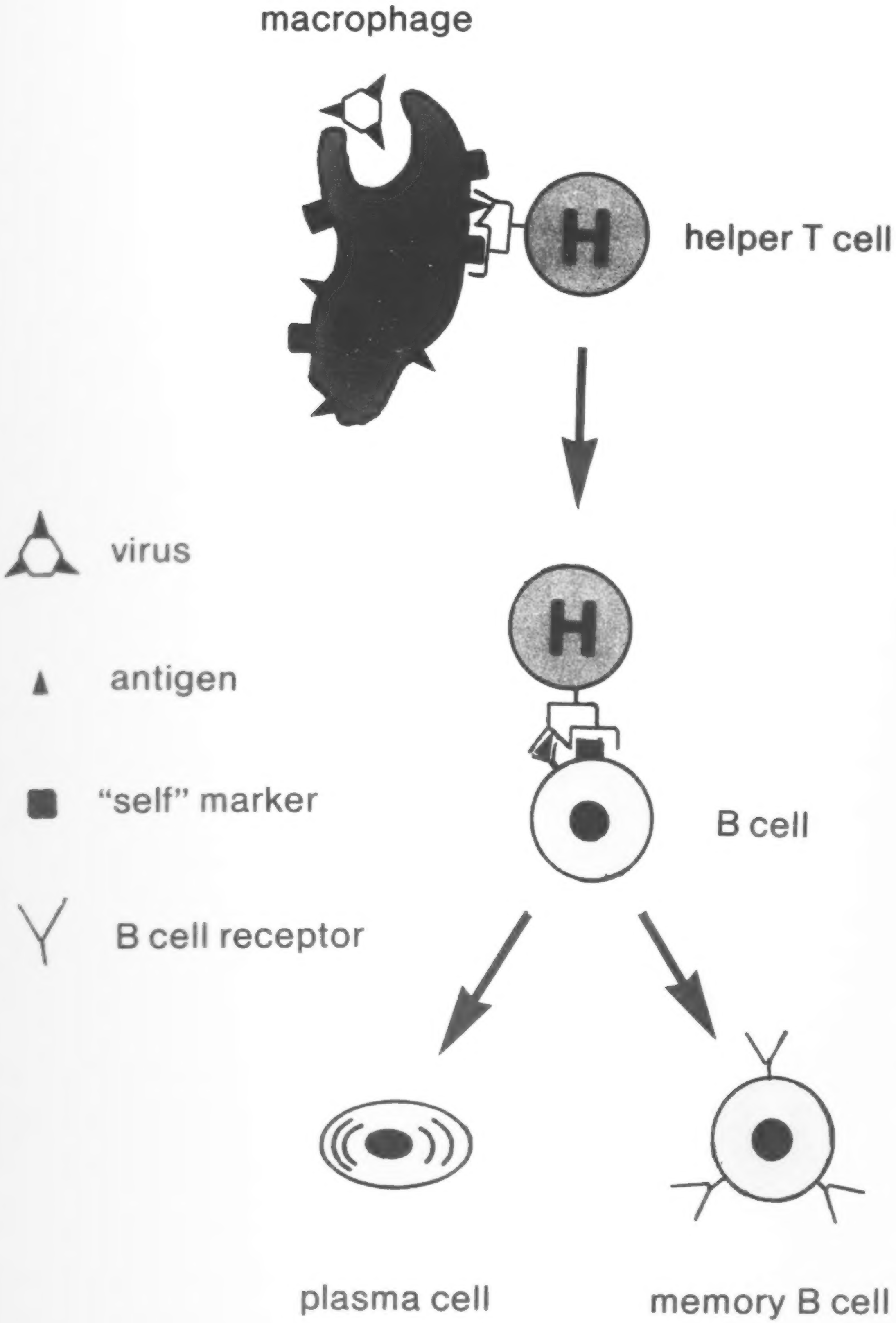
Electron transport system

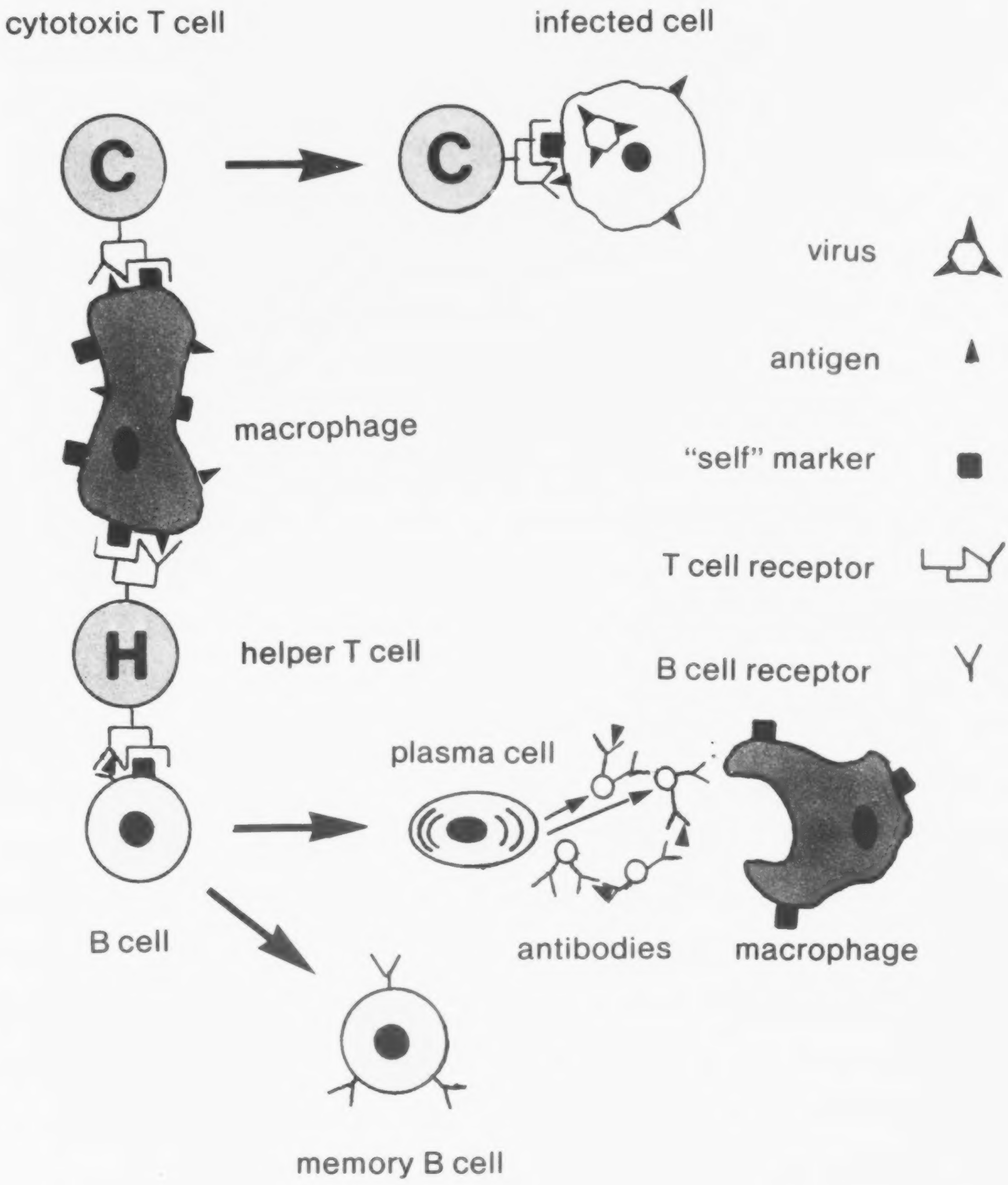

inner space of mitochondrion
intermembrane space
e^-
H^+
+
A -P-P
A -P-P-P
outer membrane
inner membrane
O_2
H
H_2O

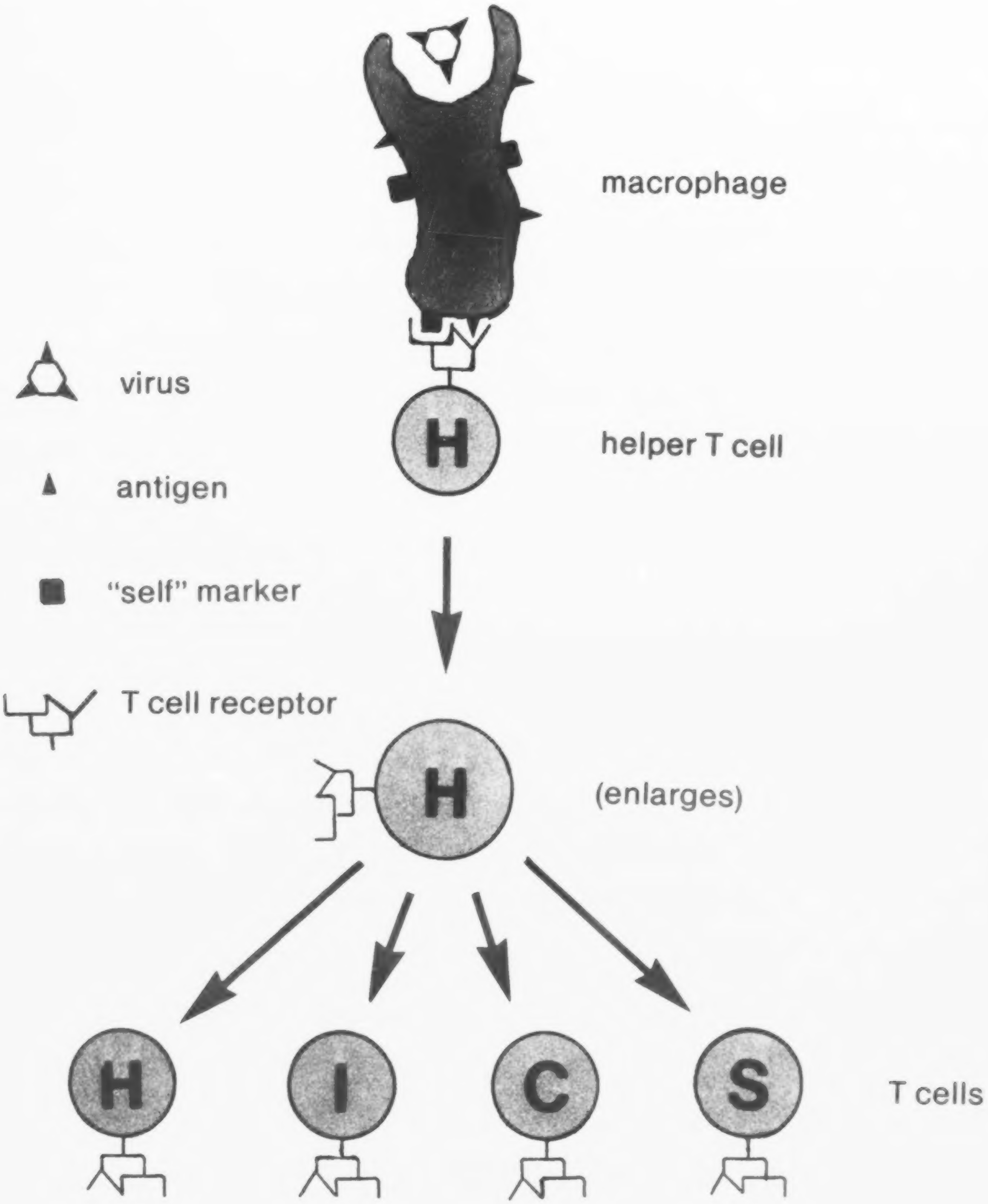

polysaccharides
monosaccharides
C
C
C
C
C · C
C
proteins
fats
glycerol
amino acids
fatty acids
Glycolysis
ATP
C · C · C
cytosol
mitochondrion
Intermediate reactions
CoA
C · C
6
Krebs cycle
hydrogens
Electron transport system
ATP
ATP
ATP
O_2
H_2O

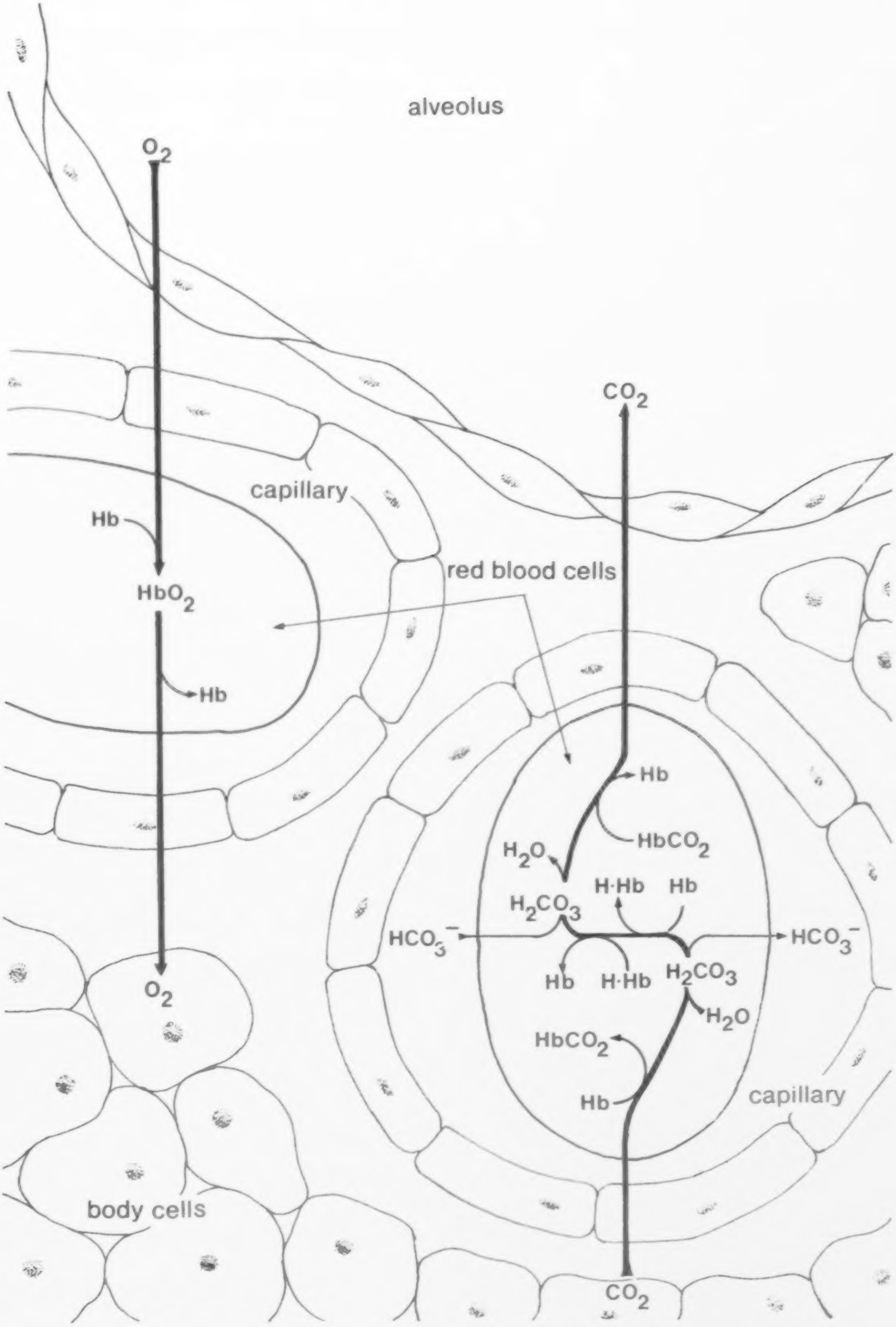

c
b
a

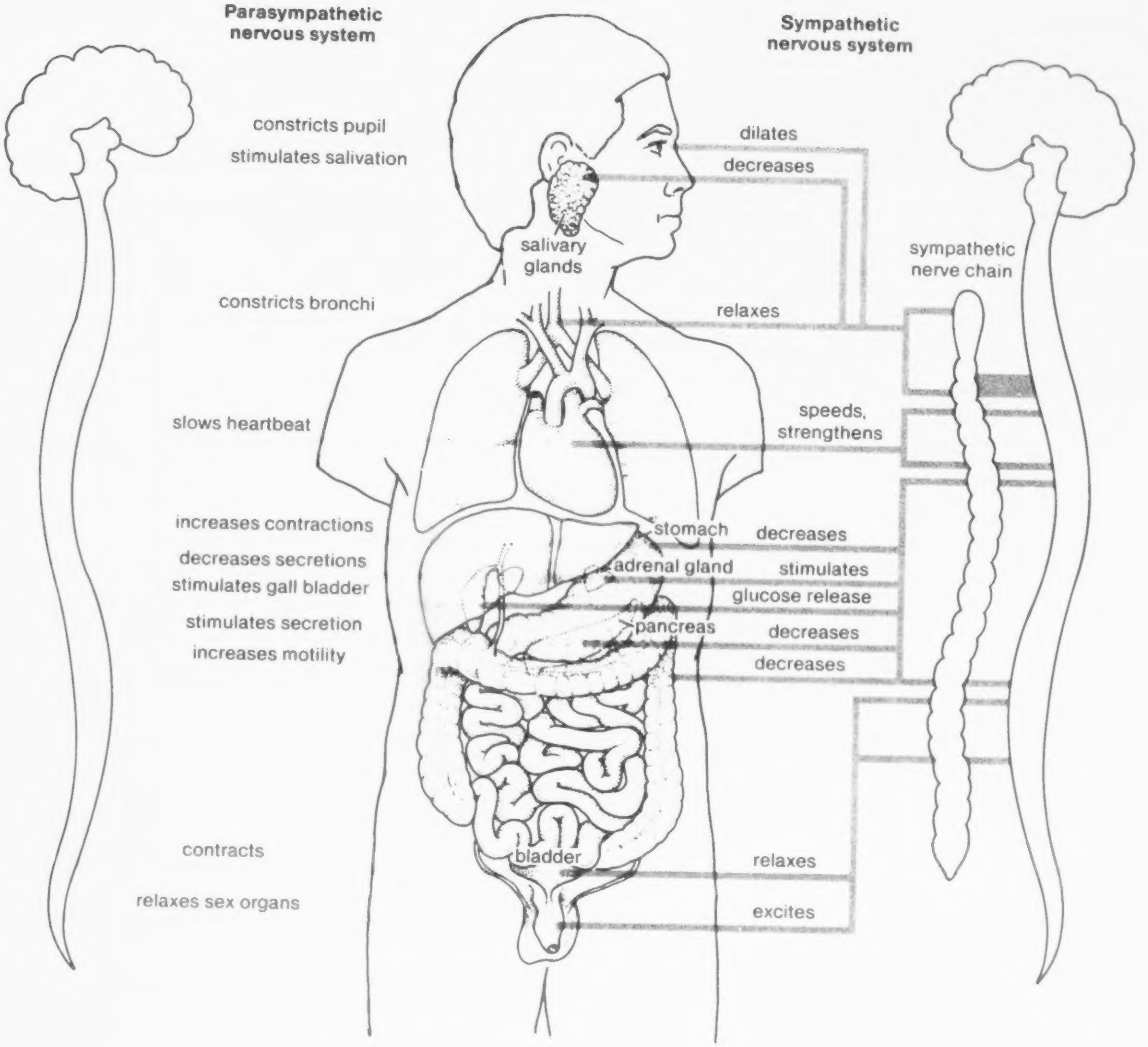

B cells
T cells
H
I
C
S
macrophage

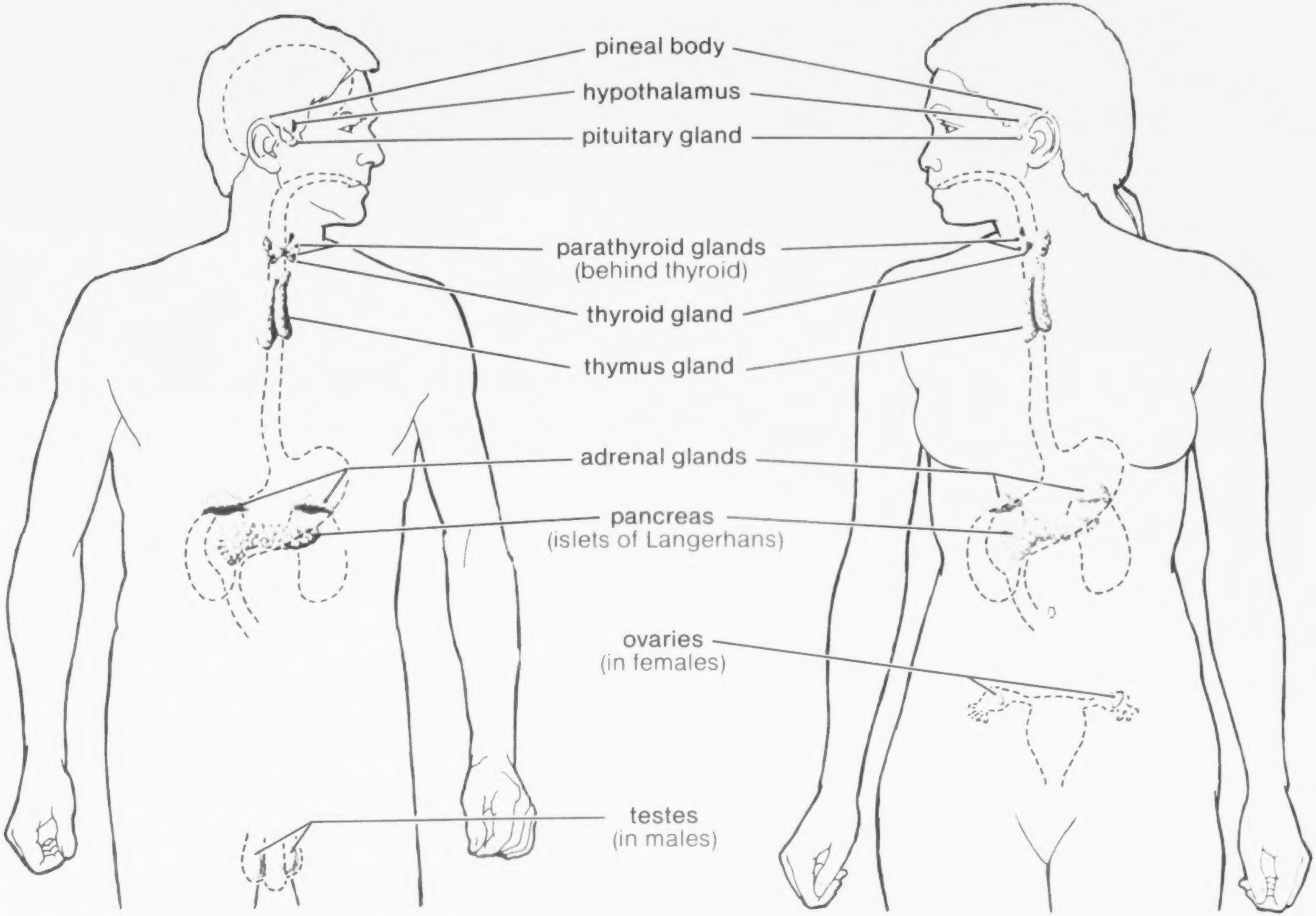

macrophage
helper T cell
H
virus
antigen
"self" marker
B cell receptor
H
B cell
plasma cell
memory B cell


cytotoxic T cell
infected cell
C
C
virus
antigen
macrophage
"self" marker
T cell receptor
H
helper T cell
B cell receptor
plasma cell
B cell
antibodies
macrophage
memory B cell

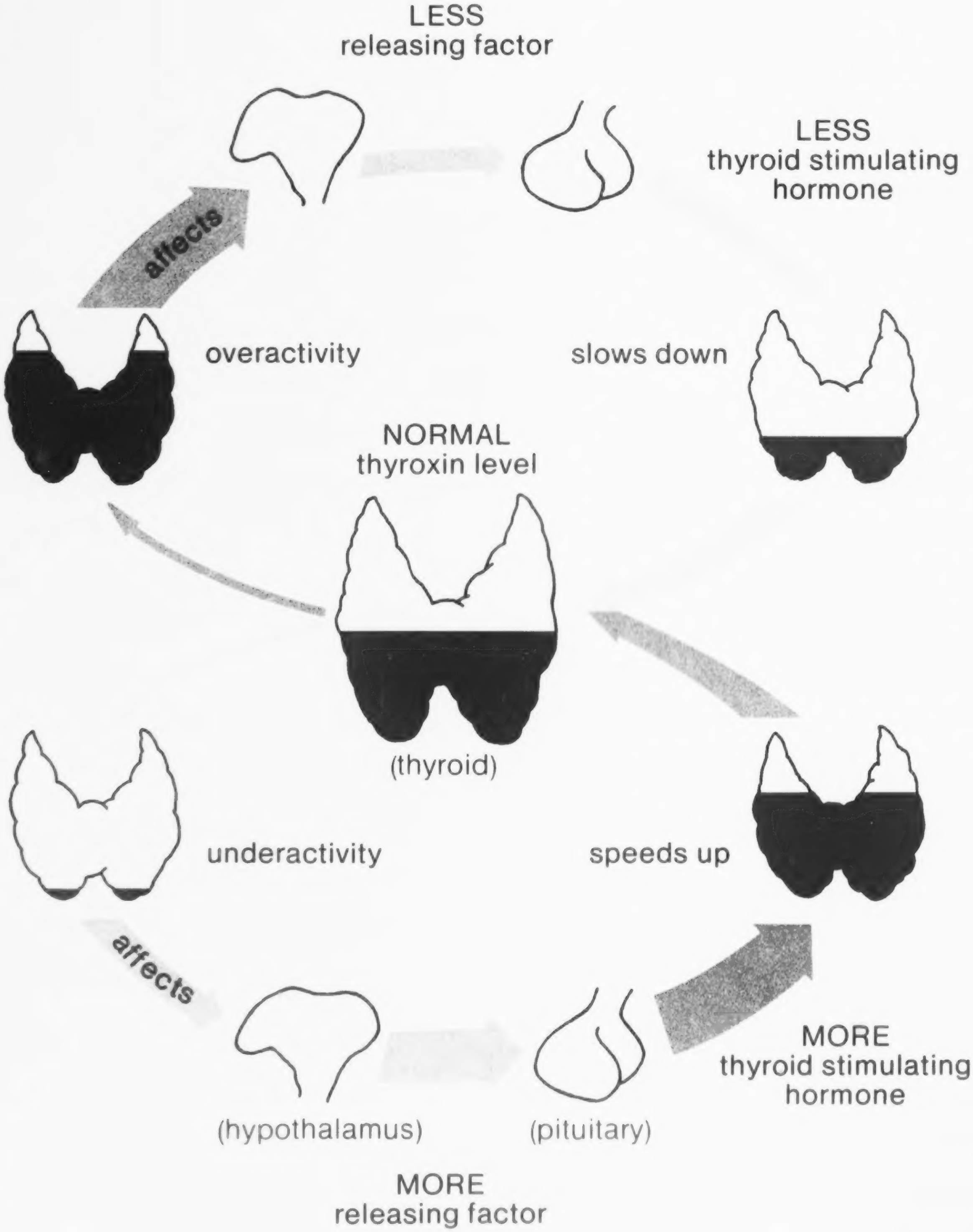

macrophage
virus
H
helper T cell
antigen
"self" marker
T cell receptor
H
(enlarges)
H
I
C
S
T cells

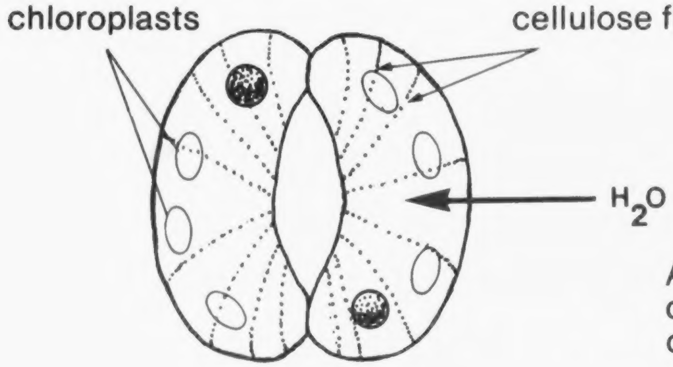

alveolus
O_2
CO_2
capillary
Hb
HbO_2
red blood cells
Hb
Hb
$HbCO_2$
H_2O
H·Hb
Hb
H_2CO_3
HCO_3^-
HCO_3^-
Hb
H·Hb
H_2CO_3
H_2O
$HbCO_2$
Hb
capillary
O_2
body cells
CO_2


Parasympathetic nervous system
Sympathetic nervous system
constricts pupil
stimulates salivation
dilates
decreases
salivary glands
sympathetic nerve chain
constricts bronchi
relaxes
slows heartbeat
speeds, strengthens
increases contractions
decreases secretions
stimulates gall bladder
stimulates secretion
increases motility
stomach
decreases
adrenal gland
stimulates
glucose release
pancreas
decreases
decreases
contracts
relaxes sex organs
bladder
relaxes
excites


pineal body
hypothalamus
pituitary gland
parathyroid glands
(behind thyroid)
thyroid gland
thymus gland
adrenal glands
pancreas
(islets of Langerhans)
ovaries
(in females)
testes
(in males)

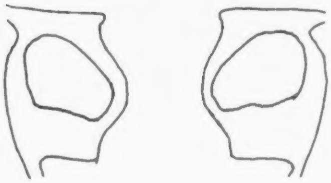
41


LESS
releasing factor
LESS
thyroid stimulating
hormone
affects
overactivity
slows down
NORMAL
thyroxin level
(thyroid)
underactivity
speeds up
affects
MORE
thyroid stimulating
hormone
(hypothalamus)
(pituitary)
MORE
releasing factor

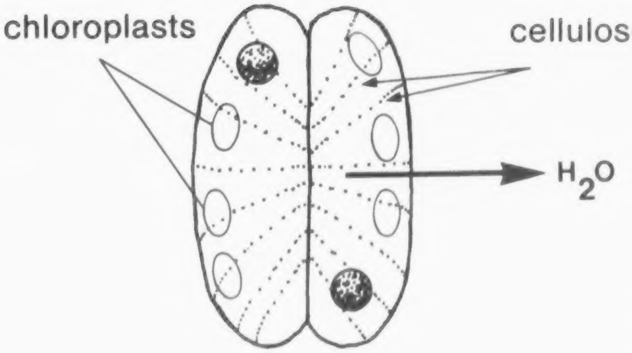

chloroplasts
cellulose fibers
H_2O

As water enters the guard cells, they elongate and bend outward, opening the stoma

top view

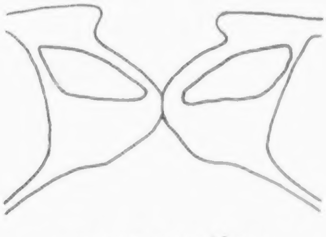


cross section

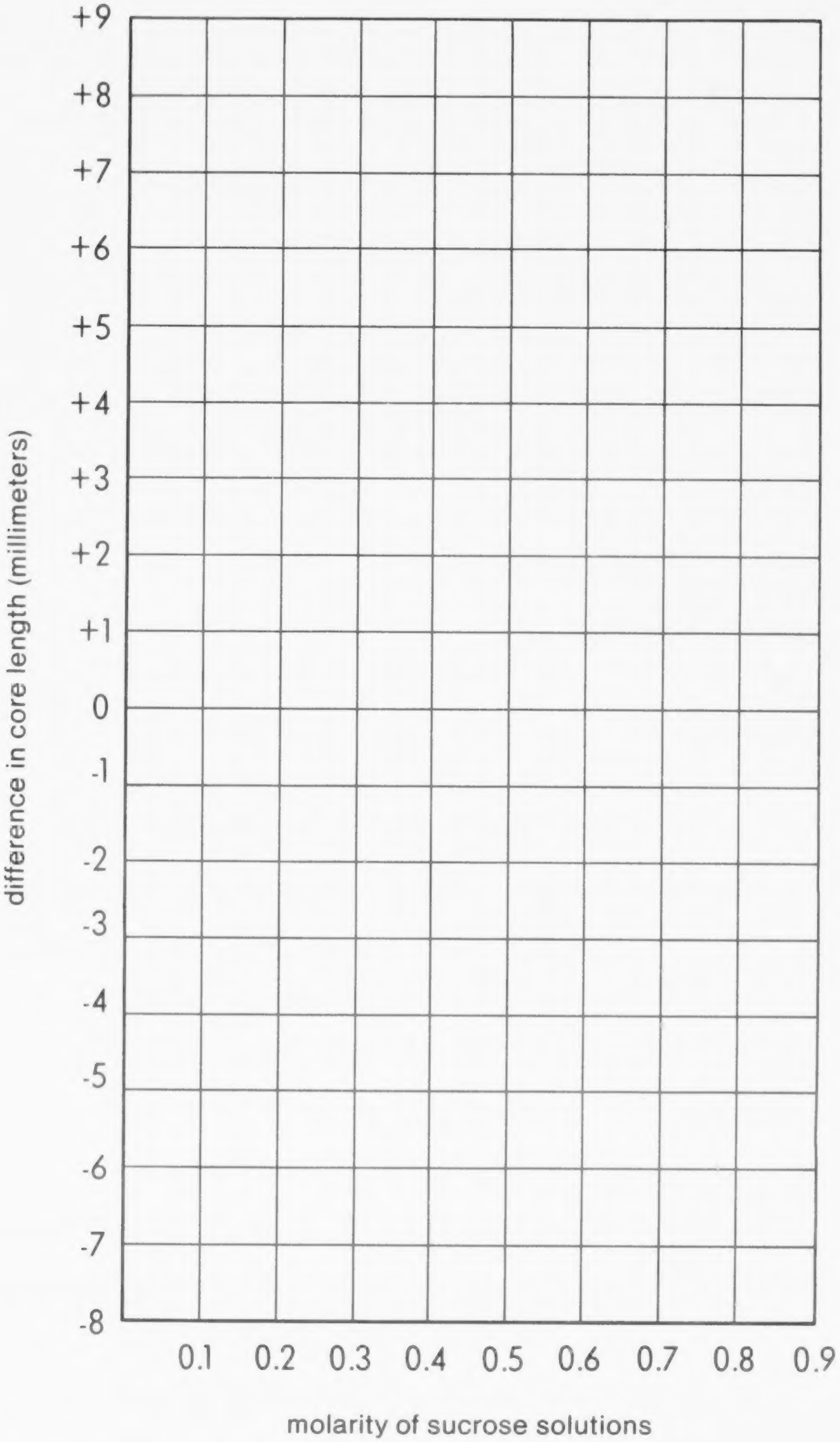

chloroplasts
cellulose fibers
H_2O

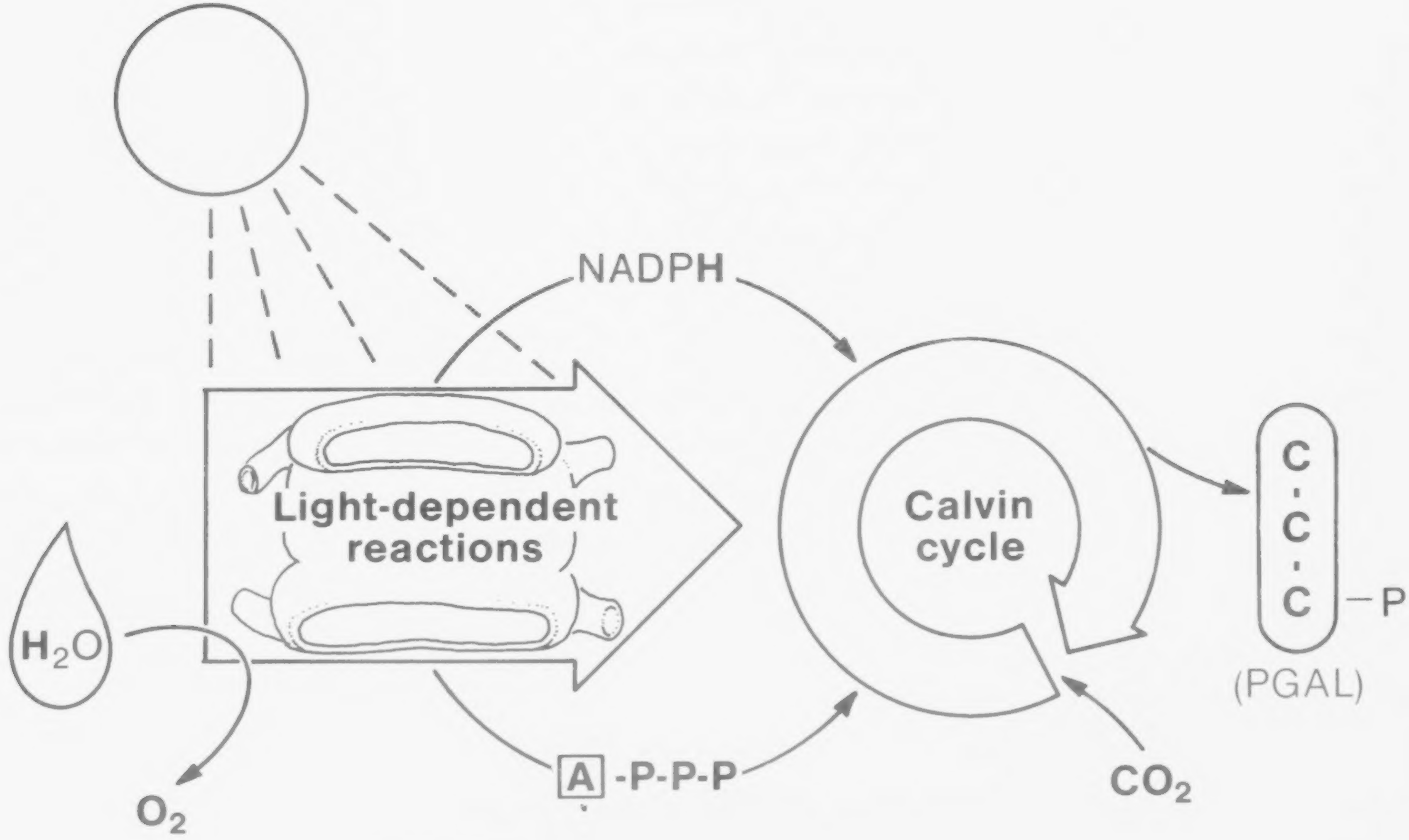
As water leaves the guard cells, they resume their shape, closing the stoma.

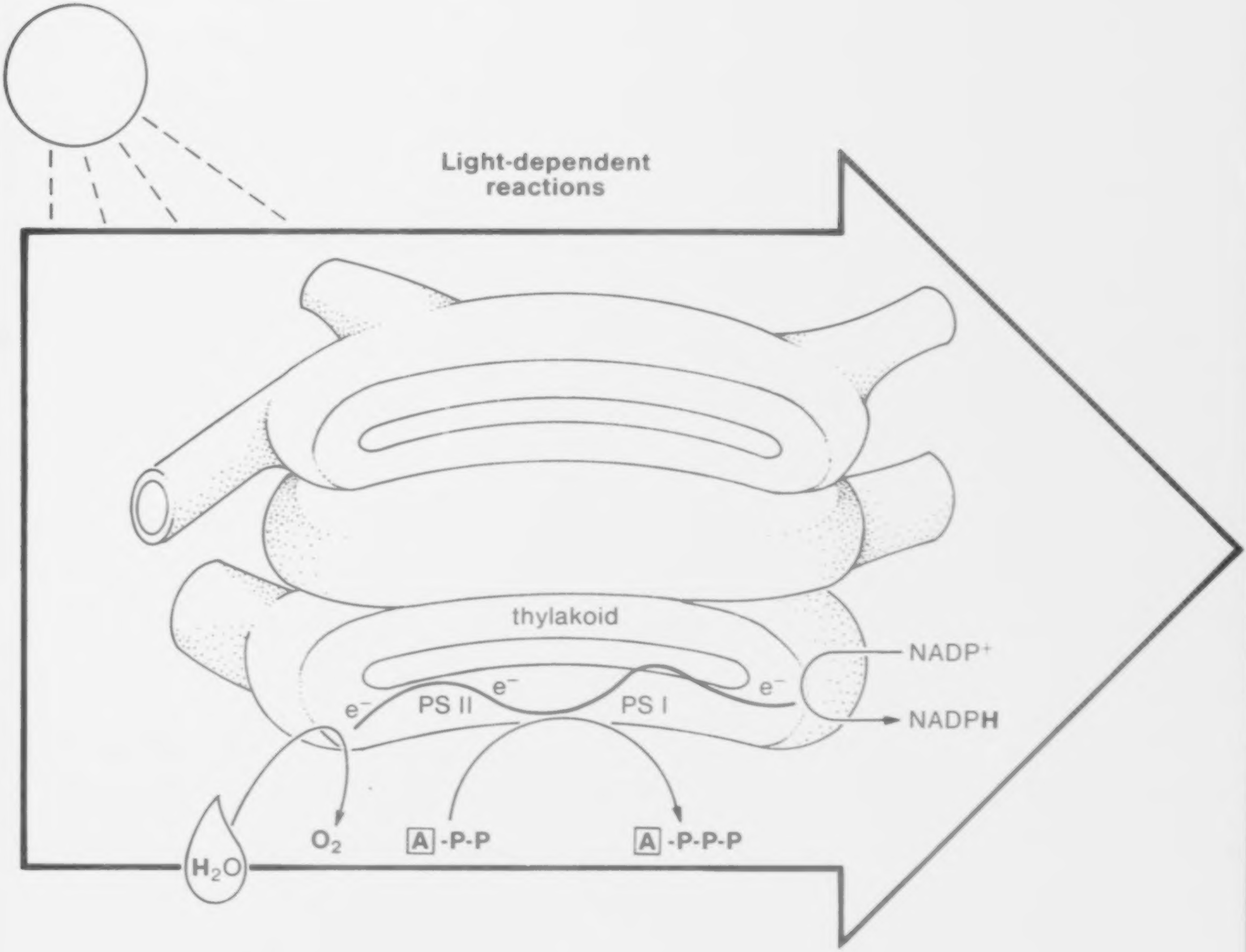
top view

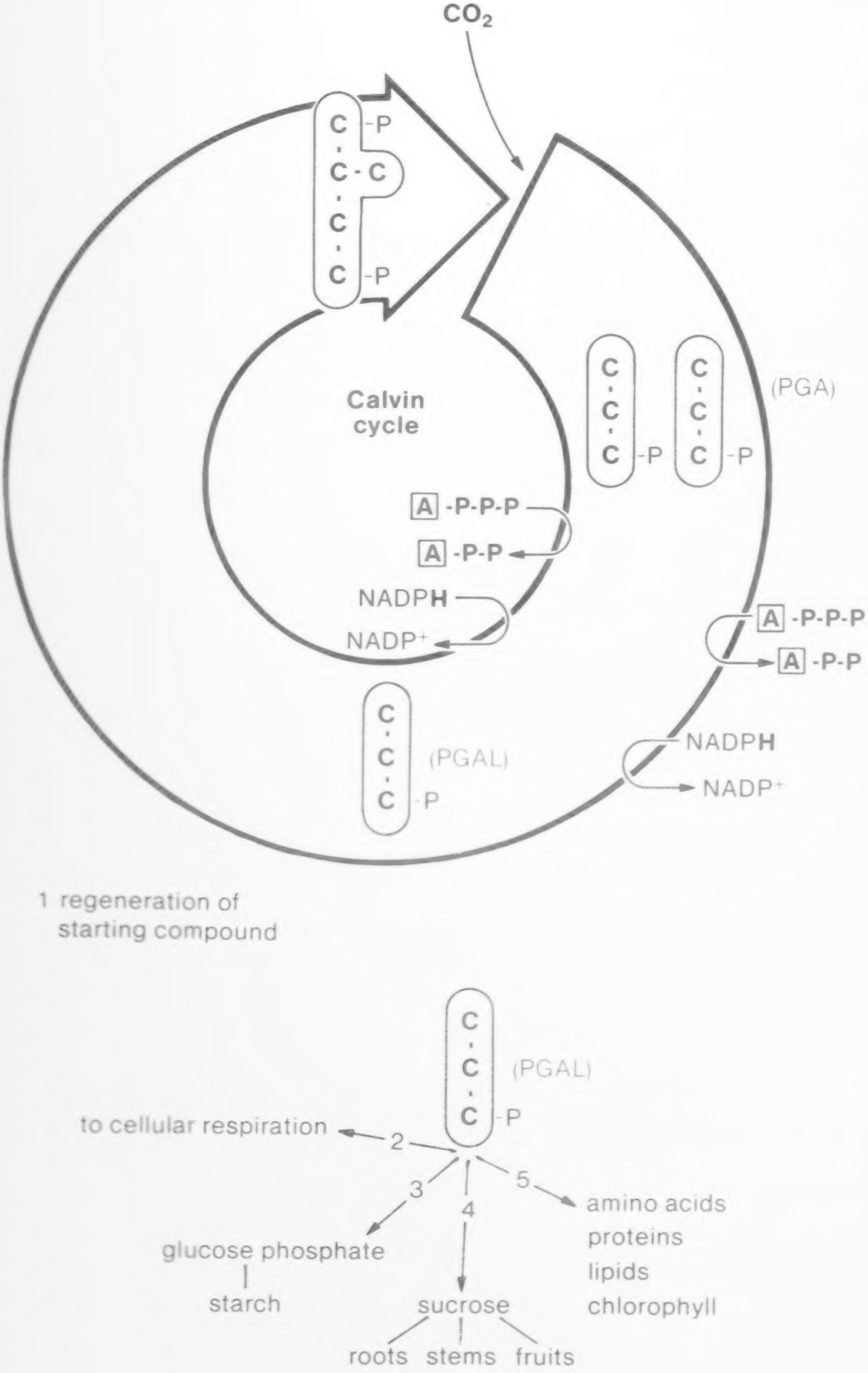


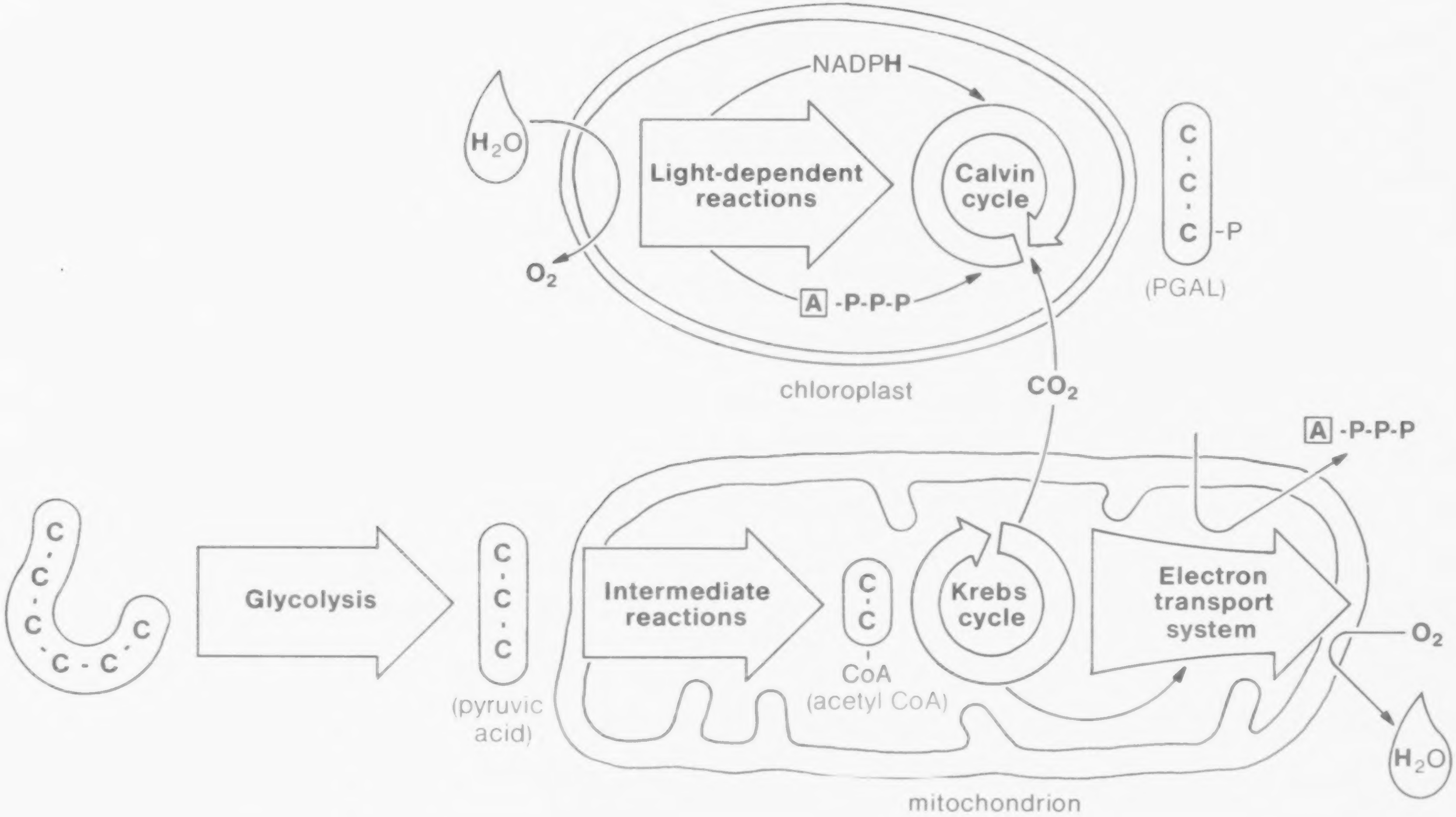
cross section

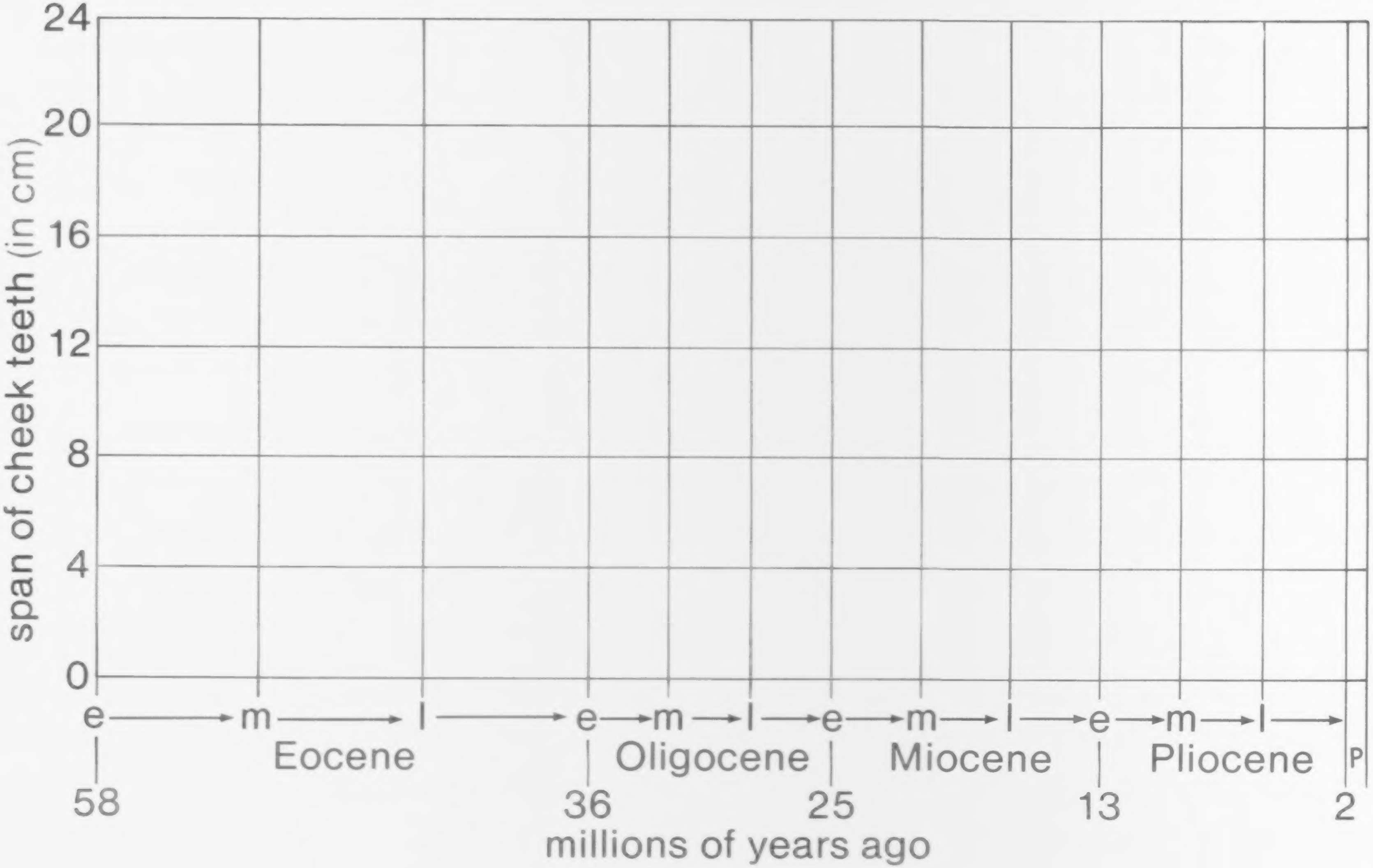

+9
+8
+7
+6
+5
+4
+3
+2
+1
0
-1
-2
-3
-4
-5
-6
-7
-8
difference in core length (millimeters)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
molarity of sucrose solutions


NADPH
Light-dependent reactions
Calvin cycle
H_2O
O_2
A -P-P-P
CO_2
C
C
C
— P
(PGAL)

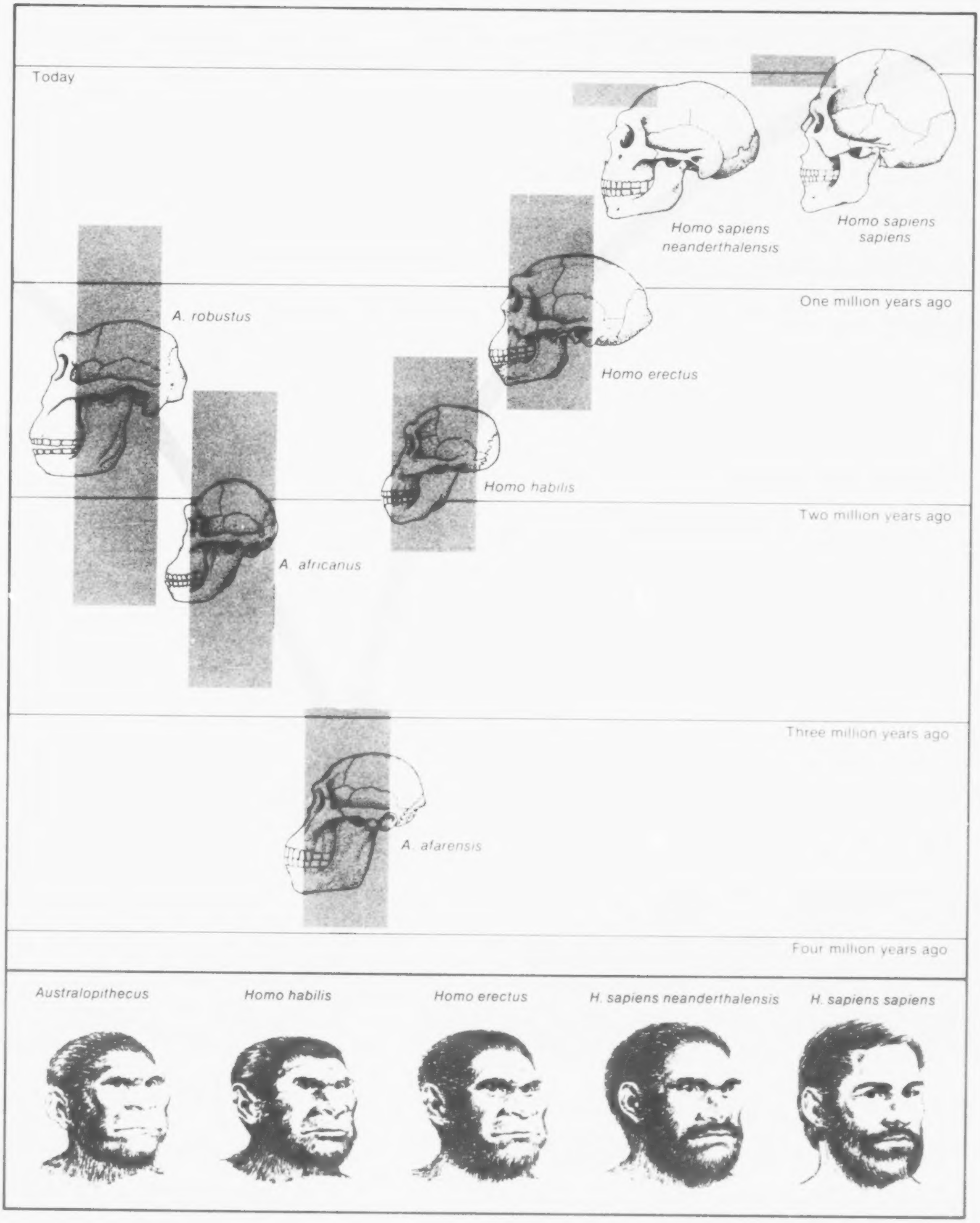

Light-dependent reactions
thylakoid
e⁻
PS II
e⁻
PS I
e⁻
NADP⁺
NADPH
H2O
O2
A -P-P
A -P-P-P

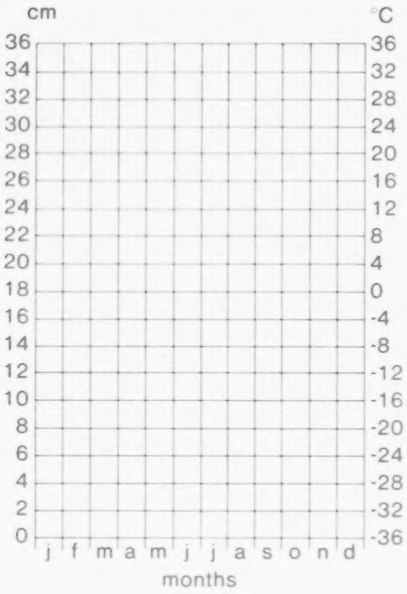

CO2
C -P
C - C
C
C -P
Calvin cycle
C C C -P
C C C -P
(PGA)
A -P-P-P
A -P-P
NADPH
NADP+
A -P-P-P
A -P-P
NADPH
NADP+
C C C -P
(PGAL)
1 regeneration of starting compound
C C C -P
(PGAL)
to cellular respiration
2
3
4
5
glucose phosphate
starch
sucrose
roots
stems
fruits
amino acids
proteins
lipids
chlorophyll

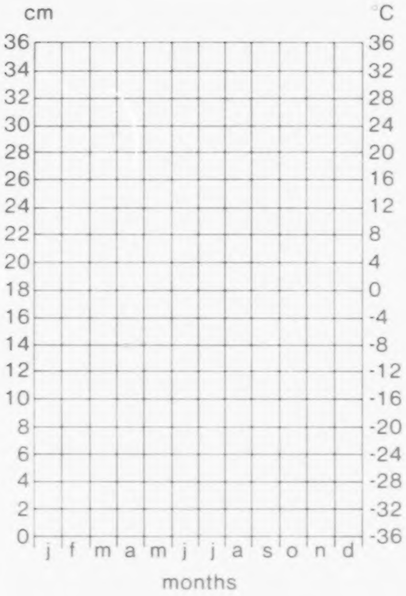

NADPH
H_2O
Light-dependent reactions
Calvin cycle
C · C · C -P
(PGAL)
O_2
A -P-P-P
chloroplast
CO_2
A -P-P-P
C · C · C · C · C - C
Glycolysis
C · C · C
(pyruvic acid)
Intermediate reactions
C · C
CoA
(acetyl CoA)
Krebs cycle
Electron transport system
O_2
H_2O
mitochondrion

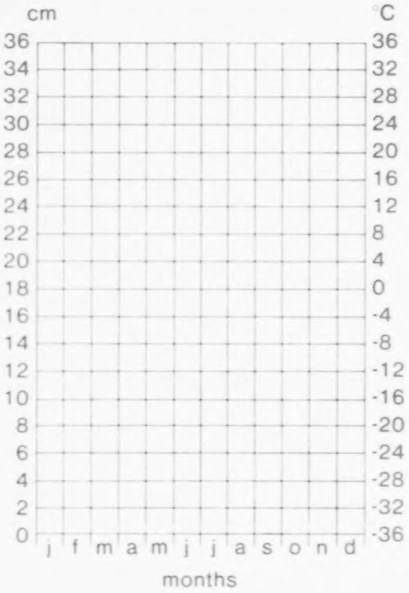


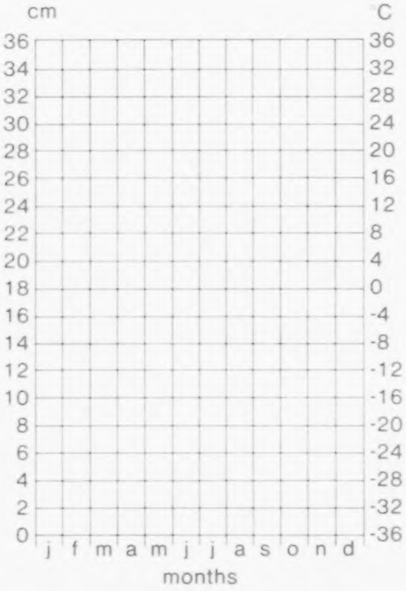
span of cheek teeth (in cm)
24
20
16
12
8
4
0
e → m → l → e → m → l → e → m → l → e → m → l →
Eocene
Oligocene
Miocene
Pliocene
P
58
36
25
13
2
millions of years ago

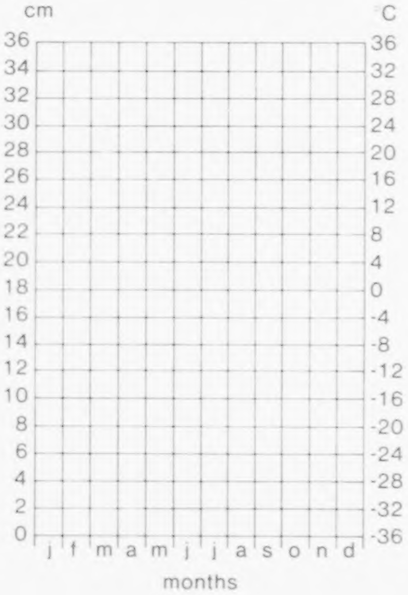

Today
Homo sapiens neanderthalensis
Homo sapiens sapiens
One million years ago
A. robustus
Homo erectus
Homo habilis
Two million years ago
A. africanus
Three million years ago
A. afarensis
Four million years ago
Australopithecus
Homo habilis
Homo erectus
H. sapiens neanderthalensis
H. sapiens sapiens

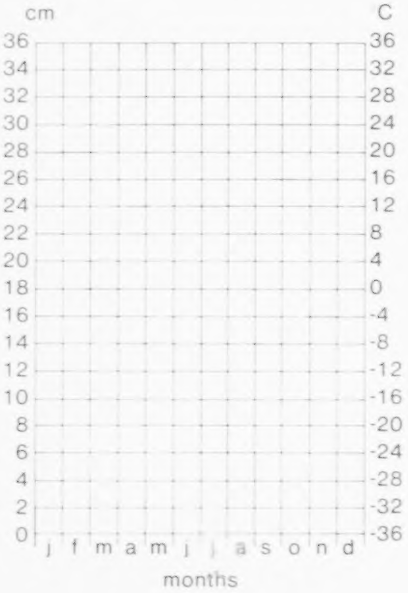

cm
°C
36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
36 32 28 24 20 16 12 8 4 0 -4 -8 -12 -16 -20 -24 -28 -32 -36
j f m a m j j a s o n d
months

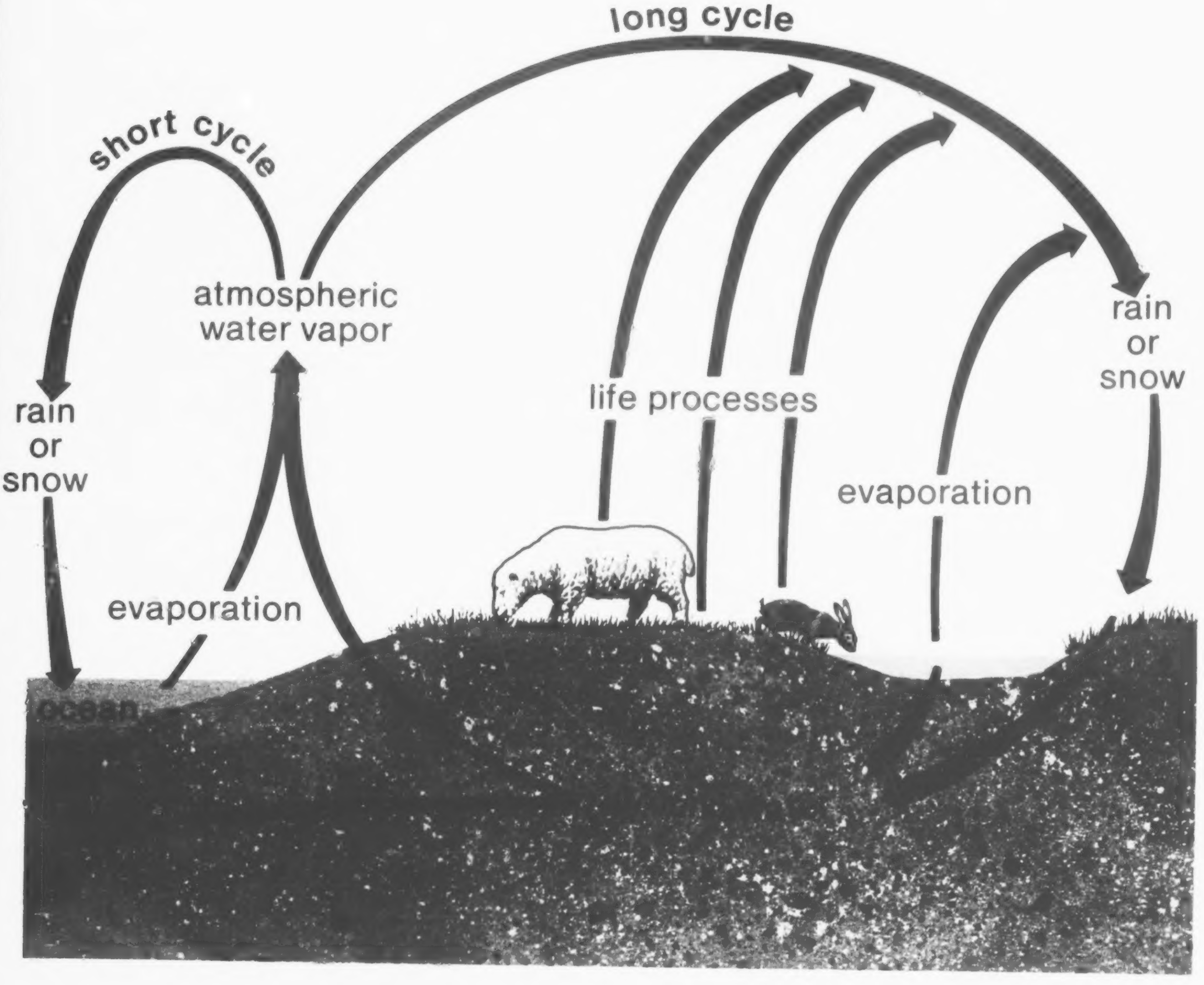

cm
°C
36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
36 32 28 24 20 16 12 8 4 0 -4 -8 -12 -16 -20 -24 -28 -32 -36
j f m a m j j a s o n d
months

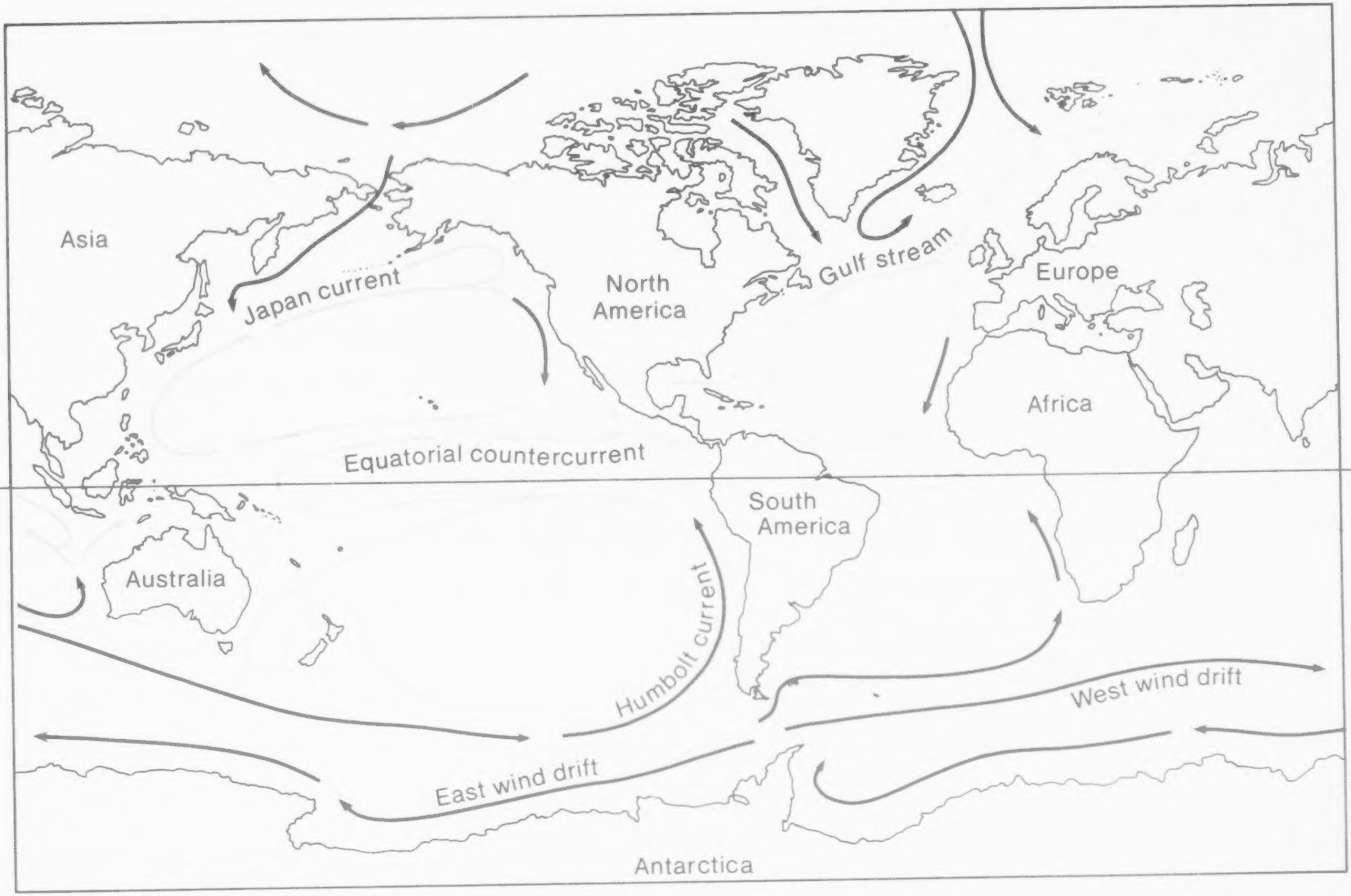

cm
°C
36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
36 32 28 24 20 16 12 8 4 0 -4 -8 -12 -16 -20 -24 -28 -32 -36
j f m a m j j a s o n d
months

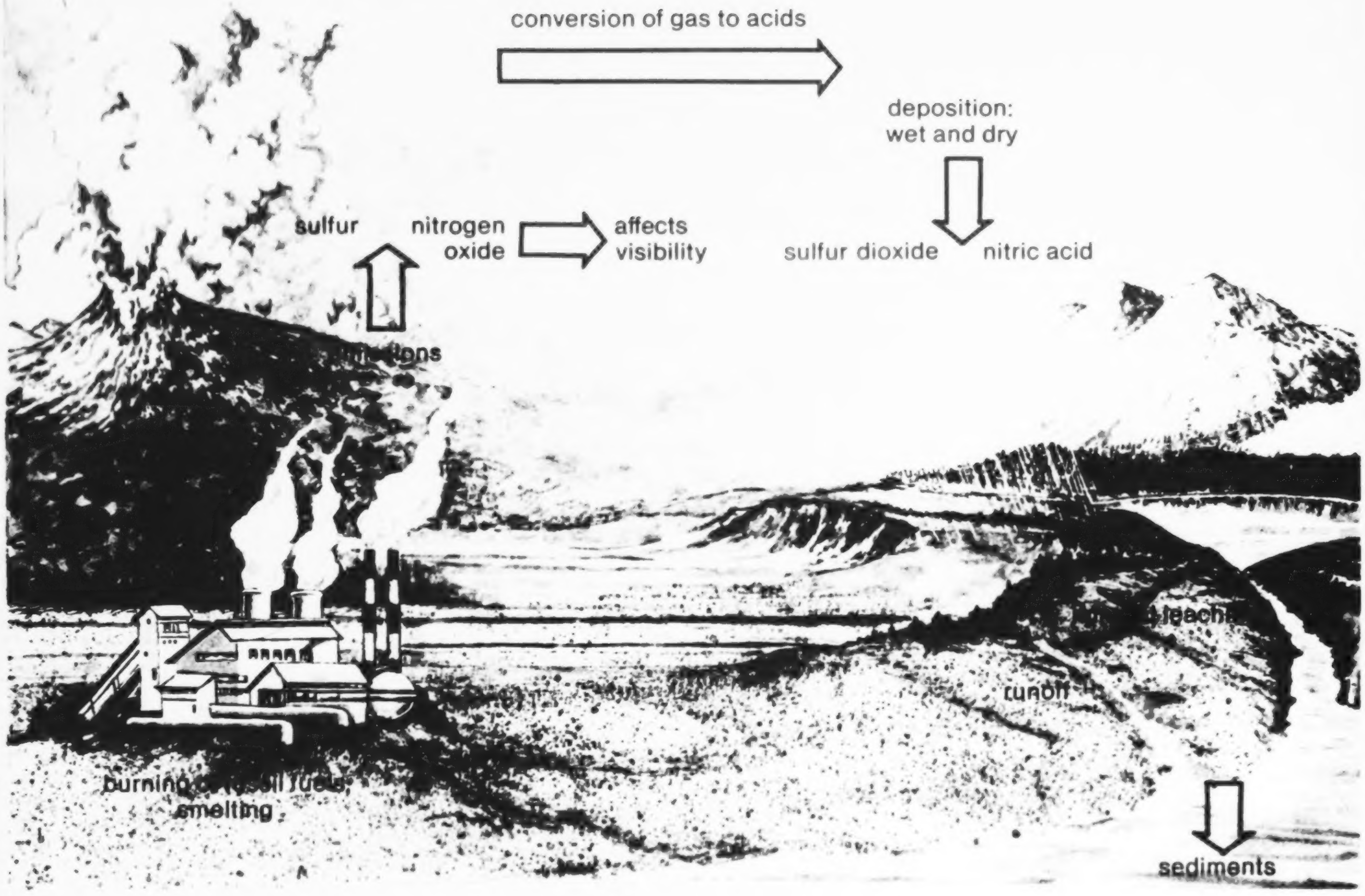

cm
°C
36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
36 32 28 24 20 16 12 8 4 0 -4 -8 -12 -16 -20 -24 -28 -32 -36
j f m a m j j a s o n d
months

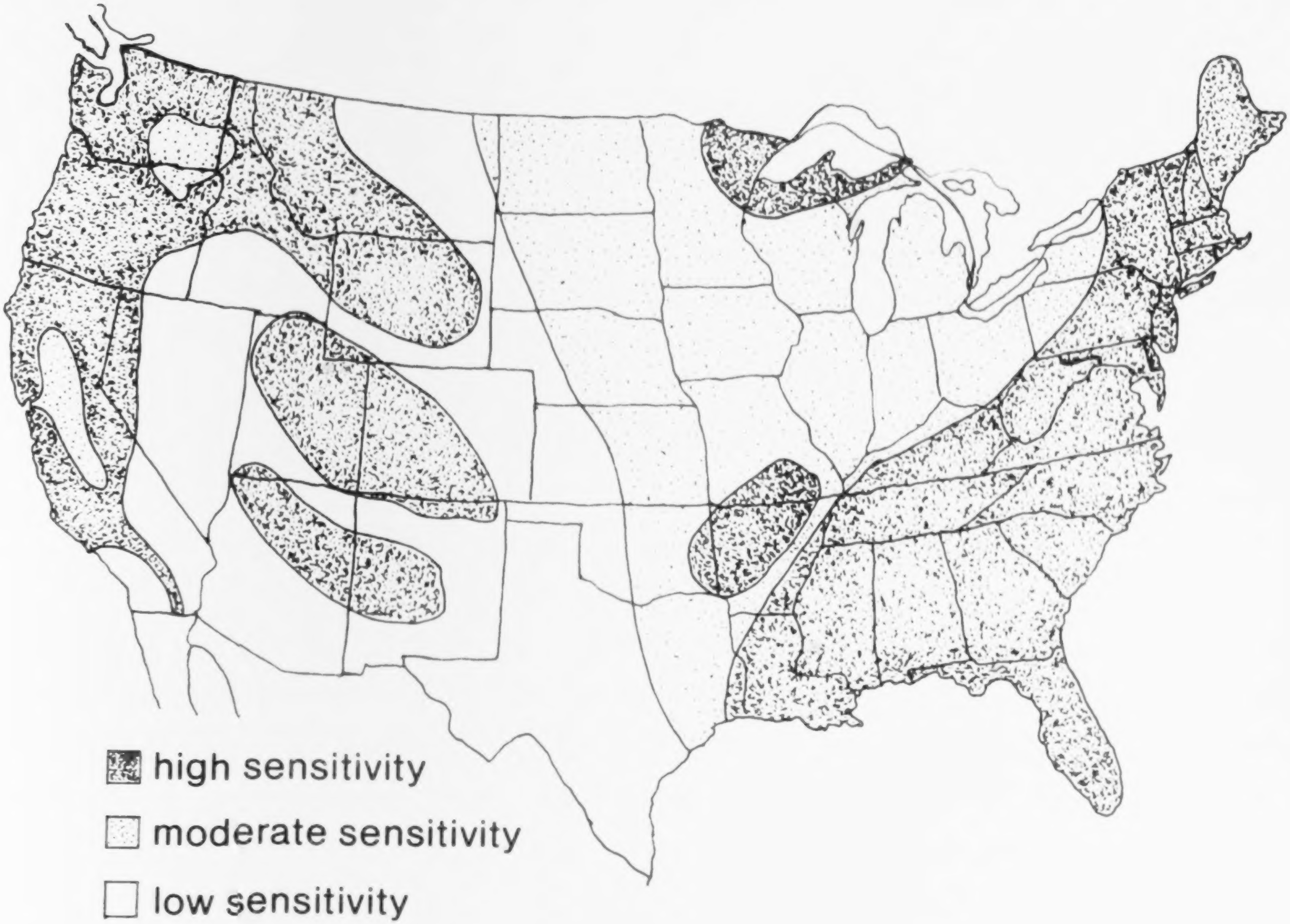

cm
°C
36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
36 32 28 24 20 16 12 8 4 0 -4 -8 -12 -16 -20 -24 -28 -32 -36
j f m a m j j a s o n d
months

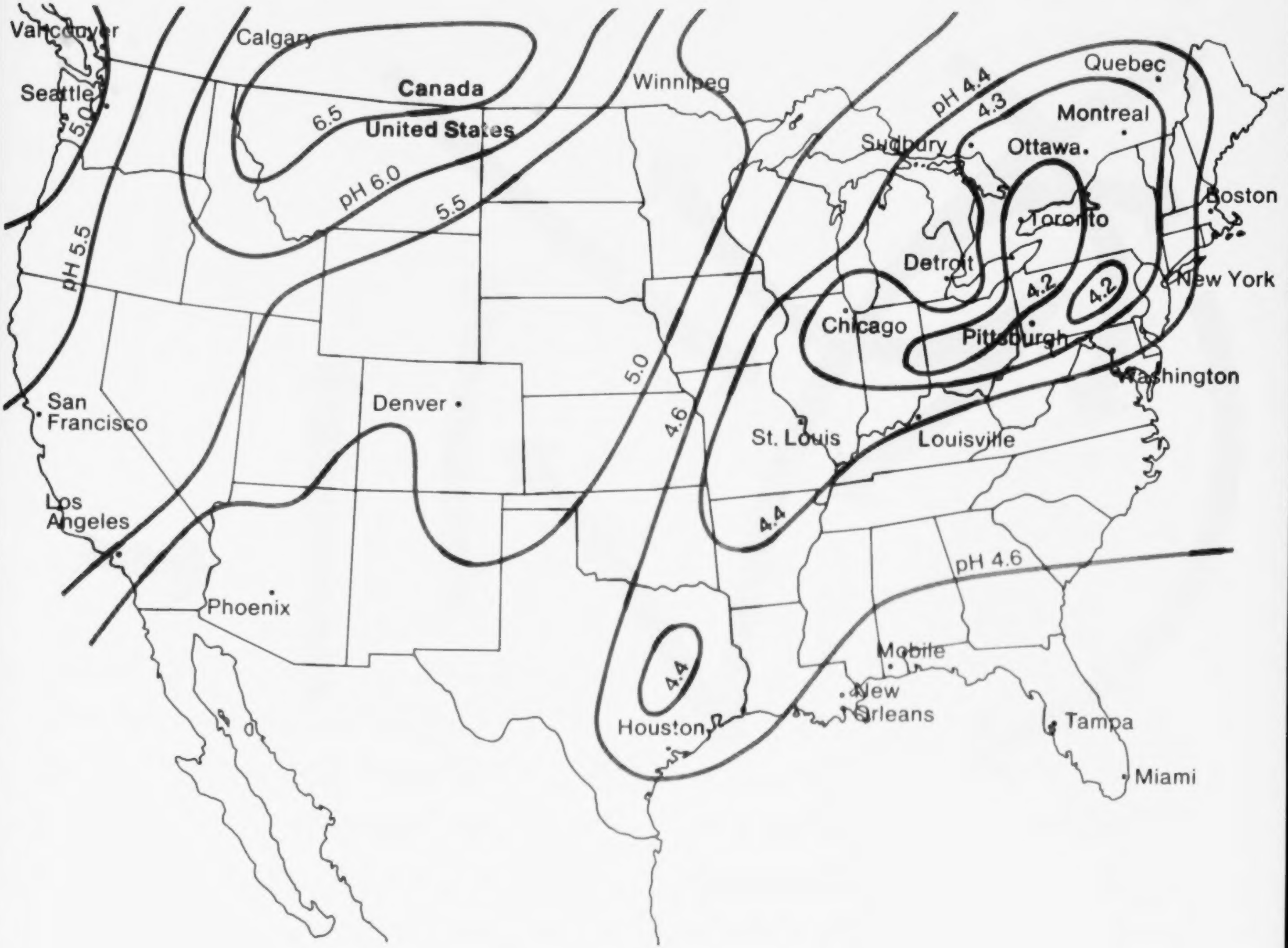

cm
C
36 34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
36 32 28 24 20 16 12 8 4 0 -4 -8 -12 -16 -20 -24 -28 -32 -36
j f m a m j j a s o n d
months


long cycle
short cycle
atmospheric water vapor
rain or snow
evaporation
ocean
life processes
evaporation
rain or snow


Asia
Japan current
North America
Gulf stream
Europe
Africa
Equatorial countercurrent
South America
Australia
Humbolt current
West wind drift
East wind drift
Antarctica


conversion of gas to acids
deposition: wet and dry
sulfur
nitrogen oxide
affects visibility
sulfur dioxide
nitric acid
emissions
leaching
runoff
burning of fossil fuels; smelting
sediments


▨ high sensitivity
░ moderate sensitivity
☐ low sensitivity


Vancouver
Seattle
Calgary
Canada
United States
Winnipeg
6.5
pH 6.0
5.5
5.0
pH 5.5
San Francisco
Los Angeles
Phoenix
Denver
5.0
4.6
St. Louis
4.4
Louisville
Chicago
Detroit
Sudbury
pH 4.4
4.3
Quebec
Montreal
Ottawa
Toronto
Boston
New York
4.2
4.2
Pittsburgh
Washington
pH 4.6
Mobile
New Orleans
Houston
4.4
Tampa
Miami